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The U. S. Steel Corporation and Electric Steel Refining.

While going to press, we are informed that the United States Steel Corporation has secured complete control of the Héroult patents for electric steel making and refining in this country. From a commercial standpoint this news appears to be of momentous importance. As well known to the readers of this journal, the Steel Corporation has had two 15-ton Héroult furnaces in commercial operation for some time, one at South Chicago, Ill., the other at Worcester, Mass. At South Chicago the electric furnace is used in connection with the Bessemer converter to make large-tonnage steel, such as axle steel, rail steel, etc. At Worcester the electric furnace is used in connection with the open-hearth to make high-grade steel for wire, etc. The operation at the South Chicago plant was described at some length in an article in our April issue (page 179). As to the further technical development of the Héroult process in the hands of the United States Steel Corporation, it may be surmised that two patents of Mr. William R. Walker, of the Steel Corporation, will come into great prominence. One recorded in our October isssue, 1909 (Vol. 7, page 450), refers to the division of the different metallurgical reactions between acid-lined converter and basic-lined electric furnace, with a view of reducing electric power consumption and avoiding losses of metal. The other patent of Mr. Walker, recorded in our September, 1910, issue, page 546, gives a prominent place to the mixer in the Bessemer converter-electric furnace combination process.

Screen Analysis.

Considering its value and importance in metallurgy and ore dressing the screen analysis is not as extensively used as it should be. As a first aid in adjusting a disordered mill it is of prime importance, and in planning a new system of ore treatment it is indispensable and equal in importance to the chemical analysis which should accompany it in some instances. Economy should result in the occasional screen and chemical analysis of mill pulp at various stages in its treatment. In this way the efficiency of any step could be ascertained, and the proper adjustment of the machines determined. Loss of valuable material could be prevented, or perhaps a barren portion of the pulp could be eliminated from further treatment. Certain steps in the process might be found useless, and could be discarded, or, on the other hand, additional refinements might be indicated which could be installed with a resulting profit.

The basis of good screen analysis is reliable screen cloth. Little good can be accomplished by the use of screening which is irregular in size of aperture or gage of wire, giving a variable number of meshes per linear inch. Conversely, the greatest good results from the use of a series of standard laboratory screens suitable to the process used in the mill, comparable in every way with the standard mill screens, and with a definite relation between the various screens in the

series, as to gage of wire and size of aperture. Such screens are obtainable as a result of the co-operation of manufacturers and specialists in ore treatment. They are not to be compared with screens made of commercial-grade metal cloth, which is notoriously irregular. The results obtained from standard screens are proportionately superior to those from ordinary screens, and are the only reliable guide for accurate work.

Metallurgical Evolution.

It frequently has been observed that old mining districts rarely become completely worked out. Their history is usually written in short epochs marked by unusual prosperity at the beginning, gradually waning to a period of depression, at which time a superficial judgment of "dead" is pronounced upon them. The development of metallurgy has a great deal to do with these periodical revivals. At first the rich ores and simple processes are used, and in the height of prosperity which follows little attention is given to the possibility of better methods of metallurgy or to the probability of encountering more complex and refractory ores. Indeed, unless extensive exploration of the mineral area is undertaken the latter point cannot be determined in time to anticipate more appropriate methods of ore treatment, so that operations are not always continued without interruption. Hence, years sometimes elapse between revivals of prosperity.

Smelting is one of the oldest of the metallurgical arts. It is likewise of limited scope, and in the development of our Western country it has followed the lines of least resistance. To-day it is a declining industry, and in some sections has been wholly supplanted by other methods. The cyanidation and chlorination of Cripple Creek ores alone have encroached on smelting to such an extent that little support is given the smelting industry from that district. In this instance the change in process has not been due to a change in the ore, except perhaps in grade, but to the fact that cyanidation offers a better return than smelting. As matters stand now it would seem that Cripple Creek would have profited more if metallurgical research and experiment had begun years ago, before the decreasing grade of the ore made such a step advisable. This would have resulted in fewer huge dumps of low-grade ore which now demand attention, and would have eliminated the spectacular feature of high-grade shipments, but in the end the progress might have been steadier and the profit greater. With the increasing use of cyanide Cripple Creek has a prospect of 50 years of steady prosperity, whereas, depending on smelting alone, it might soon become almost an abandoned district.

Another element contributing to the rejuvenation of old mining districts is the progress in ore dressing. This applies chiefly to base ores which are beneficiated to a degree which warrants metallurgical treatment, usually by smelting. The so-called porphyry copper properties which have come into such great prominence in the last few years are the best examples of the support which concentration lends to smelting, making that process available where otherwise it would not be considered. The preparation of mixed base ores for smelting offers a more complicated problem which, however, is being successfully solved. Wet dressing and electromagnetic or electrostatic separation are proving to be the salvation of many mines and districts supposed to be in the abandoned list. In Colorado this kind of treatment is receiving more than its share of attention to-day, and bids fair to renew interest in mining, especially in the older districts.

There are enough examples of the profitable treatment of ore worth only from $2 to $4 per ton to warrant the belief that as long as any ore exists in a mine or district some method will be found to extract its metals profitably. The rôle of metallurgy is one of refinement, and there are indications that the application of electrometallurgical methods to the nonferrous metals will increase that refinement to a degree that may eliminate the necessity for mechanically enriching low-grade ores. Each step in a process involves certain unavoidable losses, and the fewer the steps the greater the saving, as a general rule. Hence the advisability of considering the applicability of new methods before the necessity for using them arises.

Cyanamide and Electrolysis versus Cyanide in Gold Metallurgy.

The process of Mr. John Collins Clancy, described at length in this issue, represents a noteworthy departure from present cyanide practice. Since cyaniding was introduced into commercial gold metallurgy by MacArthur and Forrest some twenty years ago, many changes and improvements have been made in the cyanide process. But all of them have been more or less of a mechanical nature, in the way of arranging the apparatus, while the chemistry of the process has been little changed in its principles. In this respect Mr. Clancy's process means apparently a radical departure. He proposes to substitute cheap calcium cyanamide for part or all of the sodium cyanide and potassium cyanide now used; this means a considerable saving. On the other hand, he combines the use of cyanamide with electrolysis, and this looks at first glance like a certain complication. However, the electrolytic part of the Clancy process is absolutely different from other electrolytic cyanide processes formerly proposed or used; it may especially be pointed out here that the Clancy process has to do essentially with the solution of the gold, not with its precipitation from solution. The mechanical simplicity of the electrolytic apparatus is noteworthy. The ordinary agitating tank is used, provided with graphite and iron electrodes. While nothing can yet be said about the length of the life of the electrodes in practice, yet it would seem that mechanically there is little complication involved and that the construction of the apparatus may be as robust as desired.

The keynote of the process would seem to be the use of cyanamide. As this is a substance hardly well known to practical metallurgists, a few words may be said on the interesting and in parts amusing history of the discovery of cheap cyanamide manufacture in the electric furnace. It is an example of the fact that chemical reactions do not always occur according to the chemical equations written down on paper, and that conclusions by analogy do not always hold good. Some ten years ago or so Frank and Caro set out to make cyanides from carbides. Barium carbide reacts with nitrogen (obtained from atmospheric air) at an elevated temperature to form barium

cyanide: $BaC_2 + 2N = Ba(CN)_2$. Frank and Caro concluded by analogy that they could make calcium cyanide in the same way from calcium carbide, which is, as is well known, a commercial electric furnace product made from lime and coke. They worked out their "cyanide process" and it was discovered only afterwards that they did not have cyanide, but had found something else quite worth while finding, calcium cyanamide. The reaction is here $CaC_2 + 2N = CaCN_2 + C$. Methods of making cyanide from cyanamide were worked out, but when it was found that cyanamide could be used directly as an effective fertilizer, this side of the problem was commercially developed and the manufacture of cyanide was laid aside. There are now quite a number of cyanamide factories in operation in Europe and one in Niagara Falls, on the Canadian side. In all of them the product is a fertilizer, which has been introduced into agriculture under the trade names kalkstickstoff, chaux azotée, lime nitrogen.

It would now seem that Mr. Clancy has stepped in where Frank and Caro had stopped—with one important difference. Mr. Clancy is not out to make cyanide as a commercial final product. Being directly interested only in providing an effective solvent for the precious metals, he uses essentially a calcium cyanamide solution and with the aid of the electric current brings it into the form of an effective solvent. Spent cyanate solutions he changes back into cyanide. To characterize the process briefly, he uses a comparatively inexpensive solution to start with and produces in it by electrolysis "nacent cyanide" as an effective solvent for gold and silver. This must be understood *cum grano salis* as the reactions in the solution are somewhat complicated and both the cathodic and the anodic reactions should be separately considered to understand the process in all its phases. At any rate, Mr. Clancy has devised a most interesting new process out of the ordinary ways, and the introduction of the process into large-scale metallurgical practice deserves close attention.

A Word on Bakelite, Ions, and Beauty.

In many people's mind there is a great gulf betweeen science and art. Yet the successful work of the scientist, whether it be a chemical synthesis of commercial value, as Dr. Baekeland's bakelite, or a new feat of pure science, as Professor Millikan's isolation of the ion and his absolute measurement of the ionic charge, elicits the same feeling of highest pleasure which we get from a work of art. There is beauty in science as in art. Even more, the methods of the scientist and the artist are essentially the same. We are only liable to forget this when the product of the research work of the scientist passes from the laboratory into the realm of commerce. Thus with bakelite now being manufactured on a large scale and becoming available for commercial use, we are thinking of its immense practical possibilities; and we are liable to forget that the synthesis of bakelite is an instance of a laboratory reaction running apparently along lines parallel to those of the subtle physiological changes which in the Japanese lacquer tree engender the substance known under the name of Japanese lacquer. But the laboratory process is quick and inexpensive and bakelite, the artificial product of the laboratory, is decidedly more resisting to chemical and physical influences than the product of Nature. The same is true of Dr. Acheson's artificial graphite which, produced in the electric furnace, is purer than graphite found in Nature and therefore superior to the latter for many practical purposes. Thus bakelite, like artificial graphite, are two examples showing that for the purpose of man the product of human endeavor may be superior to the product of Nature.

Of course, man cannot really improve on Nature's processes or methods. Nothing more is possible than to imitate or copy Nature's processes and to combine them for a certain end. But because a certain product is the goal kept in view it is possible to select the directest process of production and to produce only what is wanted. Nature does not set out to make pure graphite. Man can. Selection of those starting materials which are needed and nothing else and selection of only those processes of Nature which are essential for his purpose—these are the methods followed by the chemist in his synthesis. Now, this is exactly what the artist does—the sculptor, the painter, the poet. The artist must take Nature as it is. But for his work of art he takes only what is essential to the idea he has in mind. It is this selective copying of the essential from Nature and this absolute restriction to nothing but the essential that make a work of science or a work of art beautiful. It is for the same reason that Professor Millikan's lecture on the last day of the recent Chicago meeting of the American Electrochemical Society on his method of isolating ions and measuring their charge became one of the big features of this very successful convention. It is true, Professor Millikan's method is in the last analysis a modification of Wilson's cloud method, but by the details in which he modified it, to the final substitution of oil drops for water drops, he has selected the most direct imaginable way of getting from Nature an answer to one of the most fundamental problems of physics—the corpuscular nature of electricity and the value of the ionic charge. The method is now simplicity itself, free from hypothesis, free from anything that is not essential. And this beauty of the method is equaled by the accuracy and fundamental character of its results.

It has been truly said that while proper equipment of a research laboratory is important, yet the primary essential requirement is the chemist himself with a true spirit of research. Just as in the sculptor's workshop the sculptor is the one essential element, and marble and model and chisel are secondary. What counts in science, in industry, in art, in all progress of the world, is, after all, the man as man. Because this is universally true, it will not be out of place to quote here a few sentences on the essential elements in man from a book which has nothing to do with chemistry or engineering, but which has considerable to do with the seeking after truth—Gustav Frenssen's Hilligenlei: "We really do not require anything superhuman. We do not require men to go out to seek an empire. But while they are running after money and titles and other errors we require them to have a hope that they might find on the next meadow instead of a herd of sheep a gathering of angels; and we require them to have a restlessness expecting that they might meet at the next corner of the way, under the oak tree, the eternal being that holds quietly in holy hands the thousand miracles of all worlds and might give the solution of a few of them. This we require. For this is essential in a real man."

International Congress of Applied Chemistry.

At a meeting held on October 8, in the hall of the Chemists' Club in New York City, the presidents and vice-presidents of most of the sections of the International Congress of Applied Chemistry, to be held in this country in 1912, were elected. A few elections were held over. For the electrochemical section, Dr. Wm. H. Walker, of the Massachusetts Institute of Technology, was elected president; Prof. Chas. F. Burgess, of the University of Wisconsin, vice-president; for the metallurgical section, Dr. Jos. W. Richards, of Lehigh University, was elected president; Mr. J. B. F. Herreshoff, of the Nichols Copper Company, vice-president. When the organization of all the sections is completed a full account will be given in this journal.

* * *

Dr. Bernhard C. Hesse, who is the Secretary of the Congress, presented a suggestive address at the October meeting of the New York Section of the American Chemical Society on the relation of the American Chemical Society and its local sections to the International Congress.

He first emphasized that the utility of the Eighth International Congress of Applied Chemistry will be judged, determined and measured largely by the printed record of its deliberations and conclusions. It is essential that the printed record shall truthfully and accurately reflect the activities of the Eighth Congress.

That these activities of the Congress shall properly and completely represent the then condition of applied chemistry over the whole world is perhaps the main task of the Eighth Congress.

It is necessary that everything pertaining to applied chemistry in the United States which can be properly reported at the Congress should be reported.

In the last analysis it is the individual member who must carefully search his mind and his surroundings and ascertain whether or not there is something, no matter how small, which would be material to a correct reflection of the actual condition of applied chemistry in the United States and to report the same so that it may be properly considered.

The chemists interested in fats and oils have already taken steps to be properly represented. "Let the metallurgists, let all the chemists interested in the manufacture of heavy chemicals, and those interested in the manufacture of fine chemicals, and all the chemists of every other distinctive group of common interest come together and see to it that their interests are properly placed before the committees of the Congress having their interests in charge."

At the Congress a large number of interpreters will be needed with considerable chemical knowledge. There are four official languages used in the Proceedings and Transactions of the Congress, namely English, French, German and Italian. It is desirable to have each section and sub-section provided with chemists who would act as interpreters. Interpreters will also be needed at the Information Bureau.

Further, should it be feasible to print the papers in advance, a large number of proofreaders would be needed. These will also be needed for the daily bulletin and the minutes of the daily meetings of the various sections.

"The fact that the actual holding of the Congress is now almost two years off should not deter any one from at once offering his information and suggestions or volunteering his services whether as a source of information for a certain locality or as any other aid. A postal card notice will be sufficient. The more promptly the Organizing Committee is fully and completely informed as to what it has to provide and as to the individuals, societies and groups of men upon whom it can count and what each can or will do, the more expeditiously can that committee proceed with its work and the more closely will it approach to the complete realization of the objects and purposes of the Congress."

The offices of the Secretary of the Congress, Dr. B. C. Hesse, are at 25 Broad Street, New York City.

The Western Metallurgical and Chemical Field.

Cement Plaster.

One of the important chemical industries of Wyoming dealing with non-metallic minerals is that of the manufacture of cement plaster from gypsite. In the vicinity of Laramie, Wyo., there occur large deposits of gypsite, or earthy gypsum, being a mechanical deposit from the disintegration and erosion of rock gypsum. In the Laramie beds the gypsite occurs in a very finely pulverized condition. After stripping a slight overburden, the bed is worked with disk harrows to allow a part of the moisture to evaporate. It is then hauled in wheel scrapers to the storage sheds, taking only a comparatively thin layer of material so as to provide a uniform mixture for treatment.

The raw gypsite is charged directly into calcining kettles of 10 tons capacity. During the process of heating the material is kept in constant motion, and the temperature is gradually raised to about 400 deg. C. At about 220 deg. water begins to come off and the mass boils violently. Another period of slight boiling occurs at about 290 deg., after which the mass is comparatively quiet. The final temperature is between 340 and 396 deg., being determined by the appearance of the charge and the use of thermometers.

The kettles are discharged into storage hot pits, whence it is removed by spiral conveyors and elevators to the screen line, where about 1 or 2 per cent of coarse material is removed, reground and returned to the screen. The small quantity requiring grinding is due to the naturally fine state of the original gypsite. From the screen the plaster is conveyed to storage bins from which it is weighed in weighing hoppers, a weighed quantity of retarder added, and sacked. The finished mixed plaster is continually tested for setting time and quality. The operations described herewith represent the process at the plant of the Overland Cement Plaster Company, Laramie, Wyo.

Matte Smelting.

The smelter of the Colorado Gold Mining & Smelting Company, at Alma, Col., is the latest semi-pyritic plant blown in in this State. It is a plant of 150 tons daily capacity, with a modern matting furnace 42 x 120 in. at the tuyeres, there being nine 4-in. tuyeres on each side. The company owns the Kentucky Belle and Atlantic mines from which it receives about 30 tons of ore daily, and has leases on some other properties and dumps which, together with small lots of custom ore from the district, make up its total ore supply. The following average analyses of some of the ores show the nature of the material available.

	Ky. Belle	Atlantic	Moose	London	Old Slag
SiO_2%	45	20	20	77	35
Fe	15	45	2	4	33
Al_2O_3	20	—	—	11	—
CaO	—	—	20	1	10
MgO	—	—	12	—	—
S	8	22	—	—	—
Cu	1	0.2	—	—	—
Au. oz.....	0.6	0.2	—	0.7	—
Ag. oz.....	2	2	—	—	—

It will be seen that there is a variety of silicious, sulphide and lime ores from which to make the charge, which is made up as follows: Kentucky Belle, 600 pounds; Atlantic, 350; Moose and London, 250; slag, 600; flue dust, 200; matte, 50; limestone, 200; coke, 225.

The slag produced analyzes as follows: SiO_2, 38 per cent; FeO, 28; CaO, 14; Al_2O_3, 9. The matte carries 4 to 5 per cent copper, 4 to 5 oz. gold, 30 oz. silver, 60 per cent iron and 3 per cent silica.

Electric power generated at the plant is used throughout; limestone is obtained from quarries in the vicinity.

Consolidated Mercur.

In the annual report of the Consolidated Mercur Gold Mines Company, President John Dern makes a frank explanation of

the comparatively unfavorable situation in which the company finds itself after a year of exceptionally hard work to meet increasing difficulties. The company operates mines and cyanide mills at Mercur, Utah. Owing to the decreasing grade of ore it has been difficult to operate at a profit, and at times operations have been conducted at a loss. The average value of the ore treated this past year was about the same as last year, but there was a decreased tonnage in the hope of raising the value of the ore sufficiently to bring the profits up to normal.

The extraction was not as high as last year, due largely to the extra quantity of base ore treated, and to the refractory nature of the oxidized ore from the Brickyard mine. It has been impossible, even in the laboratory, to get as low tailings on this ore as formerly.

The report shows that 231,631 tons of ore were treated during the year, of an average total value of $3.59 per ton. The average of the tailing for the year is $0.94 per ton; expenses, $2.63 per ton. The total gold production was 29,900 oz. fine gold, the cost of production being $20.376 per oz., giving a net profit of 29.4c. per oz.

The Consolidated Mercur management has always been progressive in adopting the latest scientific achievements in the treatment of ore, and it is probable that some process will yet be worked out which will apply to its present conditions.

California Smelters.

The conflict between the smelting and agricultural interests in Shasta County, California, is proving disastrous to the former, and the output of the State in copper and silver will be materially reduced this year. The United States government is also engaged in actions against smelting operations where the resulting fumes are said to be damaging national forests. The Bully Hill Copper and Smelting Company has definitely closed its plant and curtailed mining operations on account of the government's activity. This is due directly to the government's ultimatum which provided that fume condensing devices must be installed before July 1, or an injunction would be sought to restrain smelting operations. As it was impossible to comply with these terms, the plant was closed when the date mentioned arrived.

The smelter at Coram is still out of commission on account of the determination of the agricultural element to prevent operation until the Cottrell system of electric condensation is completed, which will require several months. The Mammoth smelter of the United States Company is operating at reduced capacity with bag houses for fume condensation. This plant is interesting in view of the application of the bag house to the filtration of gases from copper furnaces. The bag house has long been operated in lead smelters, but it has not been successfully tried in copper plants until lately. The United States Company built a bag house which it was thought would suffice for its four furnaces, but it has been found that the capacity is sufficient for only two furnaces and this number only is in operation. The management is reported to be satisfied that with additional bag area the process will satisfy the requirements of the plant. The problem is largely mechanical in its nature and will be worked out.

Utah Copper Mills.

The Ohio Copper Company's mill at Lark, Utah, is handling a remarkable tonnage of ore, considering its condition and original estimated capacity. Owing to financial difficulties the mill has been equipped only in one section, which represents half the capacity of the plant. The estimated capacity of this section was 1000 tons of ore daily. Recently the tonnage treated in this section was a little more than the estimated capacity of the entire mill, or 2096 tons. When the mill is completed, as it is expected it will be this year, it will take its place among the large copper producers which have attracted so much attention during the last two years.

The plant of the South Utah Mines and Smelters Corporation, at Newhouse, Utah, is treating 600 tons of ore daily, and shipping one car of copper concentrates daily to the International Smelter at Tooele. It is expected that when the plant is in full operation under the improvements that are being made it will treat about 800 tons daily.

The Tooele smelting plant of the International company has been completed and four reverberatory furnaces are in operation. As these meet the present needs of the plant, the fifth will not be used for some time. It is generally believed that no copper smelting plant has been constructed and placed in commission with so few delays, and so nearly to the pre-arranged program as to time and cost as this one.

Utah Consolidated Tramway.

The tramway between the Highland Boy mine and the Tooele smelter is now completed and in operation. It is four miles in length with a difference in elevation of 1300 feet. Seventy-nine towers, varying in elevation from 10 to 90 ft.; support the line. Two hundred and twenty-five buckets of 8 cu. ft. capacity, weighing, with load, approximately 1150 lb., move at the rate of 600 ft. per minute. The line is operated in three sections, the first two being motor driven with 20 hp motor, and the last being operated by gravity, generating 75 hp, giving a surplus of power over that required in the first two sections. The cost of transportation is about 2c. per ton.

The Iron and Steel Market.

October, the last of the fall months in which a general buying movement in steel products could normally be expected, has brought no increase in buying except in wire products, and the wire activity is presumably due to belated buying because buyers did not take hold at the usual seasonable time.

The railroads have continued their position of being strictly out of the market except for absolutely necessary requirements. This position they will undoubtedly maintain until the freight-rate issue is settled, and this is expected next February. There have been reports that a private agreement has been reached by which the railroads will be given about half the advances they have asked for, but nothing official has, of course, been done, and if the report is correct, the Interstate Commerce Commission will have the great task of deciding which advances will be allowed and which not, of the great mass of advances for which notices have been filed and which have been suspended temporarily by the commission.

In Wall Street there has been a much better feeling and the steel trade is disposed to accept this as an augury of better things, but nothing is in sight nearer than the railroad buying expected after the rate controversy is settled. The better position in Wall Street has not materially encouraged business, such as bridge and building work, depending upon financial arrangements.

Production is slightly on the down grade, the recession being due to the gradual exhaustion of the accumulations of orders for various heavy materials, particularly rails, plates and shapes. In the lighter lines orders have been comparatively good, and, on the whole, substantially equal to the production. In wire products buying has run slightly ahead of production, so that occasionally mills have fallen somewhat behind in deliveries. In sheets, the next most active line, the enormous increase in productive capacity in the past few years tells very seriously, for there is no question that the demand in point of tonnage is well in excess of that in 1907. Since that year, however, new sheet mills have come in at the rate of about 30 per year, some as new plants and others as extensions to existing plants, largely by interests which make their steel and, therefore, feel in a strong position to meet any possible competition. The total increase in sheet rolling capacity, through the building of new mills and harder driving of ex-

isting mills, has been between 300,000 and 500,000 gross tons annually in the past three years.

Finished steel prices are being maintained quite well all along the line, but through the tacit understanding that there is no advantage in cutting rather than because the mills are comforably filled with business.

Pig Iron.

Pig iron prices continue to waver at points and occasionally to drop. Basic iron has become quotable at $13, valley, or 50 cents less than at last report, and it is by no means certain that this price cannot be shaded. In all markets the tendency to demand a material advance for first quarter or first half over prompt prices is decreasing. A sale of 6000 tons of malleable iron, for instance, has been made for equal deliveries through 1911 at $14.90, delivered Pittsburgh. The valley market, 90 cents higher delivered Pittsburgh, is quotable at $14 for No. 2 foundry, $13.50 for malleable, $13 for basic and $15 for Bessemer, these prices being for early delivery.

Steel.

The market has been very quiet, but through offerings can be quoted 50 cents to $1 less than at last report, or at $23.50 for Bessemer billets, $24.50 for Bessemer sheet bars, $24.50 for open-hearth billets, and $25 for open-hearth sheet bars. Rods, however, are firmer at $28.50, Pittsburgh.

Finished Products.

Prices are substantially unchanged.

We quote the market as follows, Pittsburgh, unless otherwise noted:

Standard steel rails, $28 at mill, except Colorado.

Plates, $1.40 for wide, $1.35 for narrow, tank quality, ¼ in. and heavier.

Shapes, $1.40 for beams and channels, 15 in. and under, zees and angles 2 in. x 3 in. and larger.

Steel bars, $1.40, base; iron bars, $1.45, Pittsburgh; $1.35, Chicago; $1.35 to $1.40, Philadelphia.

Wire nails, $1.70, base; plain wire, $1.50; painted barb wire, $1.70; galvanized barb wire, $2.

Black sheets, 28 gage, $2.15 to $2.20; galvanized, $3.15 to $3.20; blue annealed, 10 gage, $1.60 to $1.65.

Tin plates, $3.60 for 100-lb. cokes.

The Non-Ferrous Metal Market.

During the past month there has been little change in the status of the base metals. The reduction in domestic stock of copper has had a stimulating effect on the market for that metal. Tin has commanded a premium for spot deliveries, but the tone of the general market has not been strong, as evidenced by the reshipment of 200 tons to London. Lead has been very steady, but zinc was weak and the demand was so light that it is believed that stocks are accumulating in the hands of the smelters.

Copper.—The figures of the Producers' Association for September showed a decrease of copper stocks of 20,087,531 lb., and this had the effect of stimulating action among the dealers and speculators. Lake copper is quoted at 12¾ cents to 12⅞ cents, with electrolytic at 12.5 cents and 12.55 cents.

Lead.—The market has been steady at 4.40 cents, New York, with slightly lower prices ruling in the West on account of large Western offerings. At St. Louis the quotations are 4.25 cents to 4.27½ cents.

Tin.—The shipments of Straits tin to this country and other markets have showed a decrease under last year. Business is most active among speculators and dealers, and spot tin has commanded a premium of about 1 cent. October tin was available at about 36½ cents.

Zinc.—Business has been fair, but not so voluminous as some time ago. While the smelters may be holding accumulating stocks, the expectation for a better future market is strong and they are not urging immediate sales. The New York market was 5.52 cents to 5.55 cents, New York, and 5.37 cents to 5.40 cents, St. Louis.

Other Metals.—Business has been only fair in aluminium, antimony and mercury, with prices almost nominal. Aluminium is offered plentifully at 22 cents, and sales have been effected at a lower rate. Antimony prices are unchanged and range from 7¼ cents to 8⅜ cents for various grades.

CORRESPONDENCE

Determining Thermal Conductivity

To the Editor of Metallurgical and Chemical Engineering:

Sir:—In the advance copies of my American Electrochemical Society paper, presented at the Chicago meeting, there are some misprints in the formulas, which should be corrected by those who wish to use them.

Page 8, in the second formula, there should be decimal points in the places left for them, namely, to the right of the first figures. Page 9, in formula 5, the n should be an r, and in formula 6 there should be a square root sign before the n.

Philadelphia, Pa. Carl Hering.

Autogenous Welding of Thermo-Couples by Direct Fusion.

To the Editor of Metallurgical and Chemical Engineering:

Sir:—In industrial thermo-electric pyrometer installations it is universally recognized that the fusion of the wires forming the hot junction of the thermo-couple is indispensable, as otherwise the prolonged heating which these couples have to undergo in permanent installations has the effect of causing the wires to become loosened, if they are merely twisted together, resulting in bad contacts and subsequently incorrect readings.

The ordinary method adopted for this fusion of couple wires used at high temperatures necessitates the use of compressed oxygen, or if the alternative method of soldering with palladium is used, compressed air is essential.

Fusing by the above methods is not always convenient, and occasionally circumstances arise where the adoption of either is impracticable by reason of either oxygen gas or palladium metal being difficult to obtain.

An alternative practical method for direct fusion adopted by the writer under these circumstances was to take advantage of the high temperature of the electric arc. To conduct the fusion the following method was adopted:

The couple (removed from its insulating and protecting sheaths) was clamped in a stand and the ends to be fused were twisted for a length of about 5 mm. Contact of the free ends of the couple were made to one terminal (A) of an electrical circuit containing a switch, while to the other terminal (B) was connected a short length (30 cm) of platinum wire subsequently used to form the arc.

To effect the fusion the switch was closed and the platinum wire attached to the B terminal was brought in contact with the twisted ends of the wires of the thermo-couple, being then instantly removed to a sufficient distance to strike the arc and then immediately withdrawn.

If the heating effect of the arc is allowed to continue too long, the twisted wires will fuse completely. In this event the beads of metal should be removed and the operation repeated.

The operation of fusing is quite instantaneous if successfully performed. A sufficient length of the twisted wires is fused by once striking an arc, and after a little practice the work can be effected without difficulty. The strength of current used was 1.8 amp at 440 volts pressure. The couple after annealing was calibrated, the results being entirely satisfactory.

By the help of borax as a flux platinum and copper leads may be fused by electric arc.

Ishapore, Calcutta, India. Percy Broadbent Crossley.

Co-operation and Business Stability.*

BY ELBERT H. GARY.

One of the most important business matters at this time, and perhaps at all times, is the maintenance of stable conditions in the iron and steel industry, and to this is attached the question of prices. For periods, at least in the past, unsatisfactory conditions have been the rule and not the exception. Violent, sudden and wide fluctuations in prices have occurred and they have been detrimental to every one connected with the business, and to the public generally. The steel and iron industry, more or less recognized as the barometer of trade, has had an influence on general conditions for good or bad, and much of the time for bad.

We do not, and never have, advocated fixed, unchangeable prices. If they are unreasonably high they should be lowered, and vice versa. If for any good reason at any time we are convinced that the rights and interests of ourselves, our employees or our customers demand decreases in selling prices or the readjustment of prices we should be prompt to make them. This does not, however, militate against the general proposition in favor of stability as opposed to demoralization. We know, as a matter of fact, from most careful observation and an abundance of testimony from those directly affected that the maintenance of fair prices and the prevention of sudden and wide fluctuations are desired by our customers themselves.

If you suggest that many members of this Institute are purchasers or consumers of the commodities produced by others, and, therefore, may object to the position taken, the obvious answer is that they do not object. Many of them purchase with the view of converting or refining and selling the product. Many have stocks of materials on hand from time to time and cannot afford, and do not desire, to have the values of inventories reduced. Besides, consumers like to feel that they can depend upon prices which they pay as being as low as the prices which their neighbors subsequently pay. We are all purchasers and consumers of one thing or another. We sell certain manufactured products, but we buy a greater variety of products; and we like to feel that we are at all times treated as our neighbors are treated.

If we go to the tailor, the butcher, the grocer, the farmer, the railroad company, the steamship line, the telegraph office, the newspaper office, or any others having for sale that which we need and buy, we are better satisfied if we are certain we are treated like our neighbors and that there will be no sudden and material decreases immediately after we have bought and before we have had opportunity to consume the product which we have purchased.

It is pleasing to note that in much of the business transacted in this country, commercial, financial and industrial, there is a tendency toward an even, steady and continuing basis of action. It would be better for us all, and better for the country, if conditions in all departments of business were more stable and less likely to be disturbed by agitation, doubt or distrust.

It has sometimes been urged that an effort to maintain reasonable prices for iron and steel is contrary to the natural laws of trade; that it is opposed to the law of supply and demand. This we do not admit. We do not undertake or advocate anything which is unreasonable, unnatural or unfair.

Those who oppose the maintenance of fair prices when the volume of business is low on the ground that it is contrary to the law of supply and demand make the mistake of supposing that capacity to produce creates supply. The law of supply and demand means the quantity which one possesses and is willing to dispose of, and the quantity which another desires to possess and is willing to buy. Capacity to furnish does not create supply, nor does ability to purchase create demand.

It is just as illogical to say that because one is able to furnish a given quantity that is evidence of the supply as it would be to say that because another can use and has money to pay for a certain quantity that constitutes a demand. The whole question should depend upon mutual consideration and decision. The seller should never take advantage of the necessities of the consumer to unreasonably advance prices, nor should advantage be taken of the necessities of the producer to secure this product at an unreasonably low price.

What then should the manufacturer do at times when the consumers or purchasers are not willing to pay the price demanded, however reasonable it may be? Many of us at least believe he should reduce the output to meet the demand, much or little, and wait until those in need are willing to pay what is fair and right. Remember this assertion is based on the assumption that prices at all times must be fair and reasonable and subject to reductions or changes whenever it is decided they ought to be made. Such reductions, however, should be made only after due consideration, and in an orderly way and not as the result of panic.

On the other hand, if prices are at any time higher than they ought to be, the consumer, whatever his pecuniary ability to pay may be, should wait until the prices are reduced. If the attitude of both seller and purchaser should be as suggested, it would not be long before they would get together on a proper basis, especially if what we advocate shall be carried into actual effect.

What has been said is outside of, and without reference to, any question of special privilege, or undue advantage, or improper control of any commodity which would enable the producer from motives of cupidity or otherwise to fix or maintain unreasonable prices, or to take advantage of the necessities of the consumer. The great aggregations of wealth make this question important, but it may not be appropriate to discuss the same at this time.

Now, how shall we bring about the conditions which have been suggested as ideal?

The existence of this Institute and the large attendance on this occasion furnish the answer.

Real, hearty, cheerful and continued co-operation on the part of the members will secure results which should be entirely satisfactory. Frank and friendly intercourse; full disclosure of his business by each to the others; recognition by all of the rights of each; a disposition to assist and benefit each other so far as practicable and proper; conduct founded on the belief that healthy competition is wiser and better than destructive competition; all these are desirable and necessary and will be effective.

Some of you may say that in your opinions, based on the past, a fair and just equilibrium cannot be maintained except as the result of some agreement on the part of those who are interested. It is a sufficient answer to make that you have no right to enter into such an agreement, express or implied, that the laws of this country are opposed to it.

But, as stated by the Attorney-General of the United States in his argument before the Supreme Court in the Standard Oil case, the law does not compel competition; it only prohibits an agreement not to compete. If competitors are in frequent communication and make full disclosure to each other in regard to their business, notifying one another of what they are doing, it will follow as a natural result that no one will take advantage of the information he thus receives to act unjustly or dishonorably toward his neighbor. You know by experience that this is so, and it will become more certain as time goes

*Extracts from the presidential address of Judge Gary, chairman of the board of directors of the U. S. Steel Corporation, before the first formal meeting of the American Iron and Steel Institute on Oct. 14, 1910. Judge Gary's address began with words of welcome to the members of the Institute and visitors from abroad. Statistical data was given on the growth of the American iron and steel industry, with a forecast of future growth. A sketch of the proposed program of the work of the American Iron and Steel Institute was then given, leading to the principal subject of the address—maintenance of stable conditions by means of "co-operation." Only this part of the address is given above, but this part is given in full.—EDITOR.

by and each of us realizes more fully his obligations to others and to this Institute.

Co-operation is broadening in its application to specific subjects growing out of the activities of life. We see it in many lines of business outside of our own. We see it in this country and in foreign countries. Especially have we observed it during the last few months in the consideration of some of the matters which have demanded the attention of the Interstate Commerce Commission and other official departments.

Co-operation can be, and should be, extended to our business relations with foreign manufacturers and producers. They will meet us half way. Indeed, the presence at this meeting of so many distinguished and representative men from Great Britain, Germany, Austria, France and Belgium, respectively, is positive proof that they believe in this Institute and are friendly to its members, and have high appreciation of the efforts we have been making in the direction of conciliation and co-operation.

Whenever and however we may have opportunity to meet these gentlemen and to legitimately co-operate with them in promoting and conserving their interests as well as our own, we should do so without hesitation. We must at all times evidence a disposition to reciprocate the friendship which these gentlemen have shown, and to demonstrate to their satisfaction that we believe thoroughly in the doctrine that we are more or less bound together by business connections, and that we enjoy prosperity when they enjoy it, and that we fail of success when they fail.

Many who are present will live to see the time when the spirit of co-operation shall extend even to the government of the nations of the earth.

Again, there is no better way of advancing our own interests than to conduct ourselves in such a way as to make it certain we are endeavoring to promote the welfare of others with whom we come in contact. Uppermost in our minds should be the proper consideration of the rights of our employees.

Members of this Institute represent corporations or firms who have in their employ hundreds of thousands of men. Many of these workmen are foreigners who are not familiar with our language or customs.

Some of them have been poor and have had few advantages in their native countries, and may not be fully able to protect themselves.

Whether this be true or not we should make it certain that all are so treated that they have the opportunity to be well housed, and well fed, and well clothed. So far as we can we should lend our assistance to the improvement of the conditions of our workmen, and, of course, the wages paid should always be fair and reasonable. All of us have discovered since this Institute was formed that there were many things which we could do for the betterment of the conditions of the workingman, and we have been prompt to do them. Particularly have we made great strides toward safeguarding our employees against accidental injury.

A continuation of the efforts we have been making in this direction will result in securing a larger measure of confidence on their part, and will bring to us the consciousness that not only have we benefited ourselves pecuniarily, but, what is more important, that we have done the right thing.

Also, we should extend the spirit of co-operation to our customers. We should be sure at all times that we are treating them right. If it is claimed on any occasion by a customer that our prices are too high with respect to any commodity, we should promptly take up with him the question for the purpose and with the intention of arriving at a just conclusion. In all cases we advocate the doctrine of co-operation as opposed to independent action. We have found, particularly during the last two or three years, that we are succeeding better as we are brought into closer relations with our customers, giving them our confidence and informing them frankly of our conditions and intentions.

Copper Precipitation in the Butte District.

Editorial Correspondence.

There are precipitated each month in the Butte district about 700,000 lb. of copper from mine and tailing waters. Of this quantity about 550,000 lb. are recovered from copper-bearing mine water, and 150,000 lb. from water percolating old tailing dumps.

FIG. 1—SERIES OF TERRACED PONDS USED IN LEACHING OLD TAILING DUMP

The adjoining illustrations, Figs. 1 to 5, show the manner of leaching and precipitating at the Red Metal precipitating plant on the tailing dump of the Montana Ore Purchasing Company's old concentrating mill.

The original tailing carried about 1 per cent copper and was deposited on a bed of slime which provides a very effective impervious stratum preventing the loss of leaching water.

The dump is divided into two sections and has a total area of about 10 acres. The surface of each section is arranged in terraced ponds, as shown in Fig. 1, into which the leaching water is pumped by means of Morris phosphor-bronze centrifugal pumps. On the larger section, one 20-hp pump elevates about 700 gal. per minute to a height of 30 ft.; and on the smaller, a 15-hp pump elevates 400 gal. per minute to a height of 25 ft. Both pumps are motor driven and require but little attention. The leaching water used at this plant is mine water

FIG. 2—PONDS DRIED TO REMOVE ACCUMULATED IRON SALTS

which has been treated previously in a precipitation plant where about 95 per cent of its copper content has been recovered, leaving from 0.003 per cent to 0.004 per cent copper.

ANALYSIS OF MINE WATER USED IN LEACHING.

Constituent.	Grams per Liter.
SiO_2	0.0992
CuO	0.0225
Al_2O_3	0.1241
Fe_2O_3	0.1541

FeO	1.5082
MnO	0.0502
ZnO	0.4257
CaO	0.3936
MgO	0.2172
SO_4	3.5400
Cl	0.0234

The percolating water is collected in tunnels extending through the bottom of the dump, and is finally discharged into a sump whence it is pumped to the precipitating launders. On the larger dump the tunnels are about 200 ft. apart and have an aggregate length of 1200 ft. They are 5 ft. high, 3 ft. wide on the bottom and 2 ft. wide at the top, and timbered throughout. On the smaller dump there are but 800 ft. of tunnels. The number and length of tunnels is dependent on the nature of the ground on which the dump is formed. Porous ground which would permit heavy loss of water by seepage would require more collecting tunnels than an impervious foundation stratum. At this plant the loss by seepage amounts to about 20 per cent.

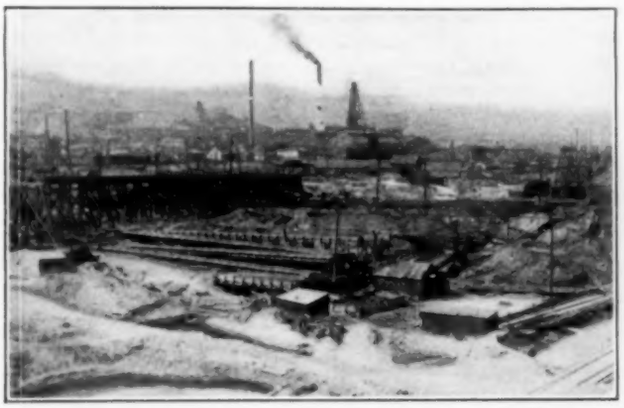

FIG. 3—BUTTE MINING DISTRICT. COPPER PRECIPITATING LAUNDERS IN FOREGROUND

As shown in Fig. 2 a section of the dump surface is allowed to dry out periodically, so that the accumulation of precipitated iron compounds may be removed and the dump material allowed to oxidize before further leaching. The rapid accumulation of iron compounds is due to the fact that the mine water used carries considerable iron from previous treatment, and on exposure to the atmosphere deposits peroxide and basic sulphate of iron. This accumulation prevents leaching and is occasionally scraped from the surface of the pond. By this treatment the dump yields a constant supply of copper, this particular dump having been leached continuously for four years with no apparent diminution in yield.

FIG. 4—PRECIPITATING LAUNDERS, GRADE ½-INCH PER FOOT

The leaching water collected through the tunnels carries from 0.015 per cent to 0.03 per cent copper. This is not as high grade as some of the mine waters, but is profitable. Figs. 3 and 4 show the launder system now preferred for precipitation rather than the tower system as shown in Fig. 6. The advantages lie in convenience of operation, particularly in charging the launders with scrap iron, and in cleaning up the copper precipitate. The launders are 4 ft. wide and 1 ft. deep, and preferably have a fall of ½ in. to the foot. Launders of this size and from 600 ft. to 700 ft. long will serve to precipitate successfully 400 gal. of copper-bearing water per minute. At the Red Metal plant the launders are 700 ft. and 512 ft. long, respectively, on the larger and smaller dumps.

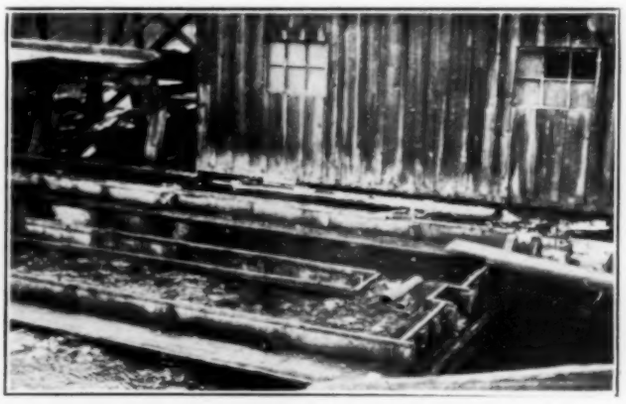

FIG. 5—COLLECTING SUMP PLACED AT THE END OF LAUNDERS

Scrap iron and tin cans are used for precipitation. Paper must be removed from the cans, and if greasy they must be burned before use. The Red Metal plant has about 75 tons of scrap in constant use, the launders are replenished with about 1000 lb. daily. Iron is consumed at the rate of 1½ lb. for each pound of cement copper produced. The precipitated copper is swept from the iron every two hours during the day, and is carried to the sump (Fig. 5) by the stream of water flowing through the launders. Thus, no handling of the iron is necessary after it has been placed in the launders. From the sump the copper is shoveled onto a drying platform and is shipped to the refinery with about 15 per cent moisture.

The recovered precipitate assays about 75 per cent copper and 8 per cent iron, with smaller percentages of other impurities. About 90 per cent of the copper in solution is precipitated in the system described. The richer the solution the more efficient the precipitation. Scrap iron is paid for at the rate of $8 per ton, although as high as $12 has been paid when copper was selling at 25 cents. Payment for the precipitates is made on the wet assay, less 1.3 per cent, and at 4 cents less than the market price for copper.

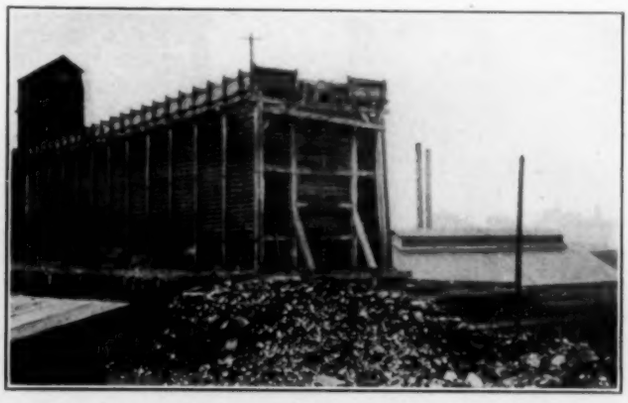

FIG. 6—OLD-STYLE TOWER PRECIPITATING PLANT AND PILE OF TIN CANS AND SCRAP IRON

Power costs $6 per hp-month. Labor cost is low, as two day laborers and one night watchman only are required at this plant, in addition to the superintendence of Mr. J. M. Gillie, to whom we are indebted for the data given herewith.

Analysis of Titaniferous Iron Ores.

By W. D. Brown.

For a long time titanic acid has been the bugbear of the furnace manager and of the chemist. However, any detriment to the furnace working due to titanic acid is largely overcome if the amount present is accurately known and the necessary precautions taken. Rossi and others have shown that titanic acid may be used in a blast furnace and fluxed as readily as silicic acid.

However, the presence of titanic acid cannot be disregarded in calculations for slags and in their analysis. Many methods are in existence for the determination of titanic acid. However, the writer has seen but little literature treating of the complete analysis of an iron ore containing titanic acid. Titanic acid if disregarded in an analysis remains with the silica or is precipitated with the alumina.

The writer has used the following method, analogous to the ordinary phosphate method, for the determination of the alumina and titanic acid on the same sample. In this method titanic acid is precipitated by a modification of the well-known method of Baskerville (*Journal*, American Chemical Society, XVI, page 427). However, it was found that this precipitate contains some alumina. This is recovered, and the total alumina precipitated as phosphate.

This method applies to the so-called non-titaniferous as well as to the titaniferous iron ores of which there are vast deposits which have not come into use because of their high content of titanic acid, notwithstanding the fact that they have a high content of iron. Probably none of our commercial iron ores are entirely free from titanic acid. The lake ores investigated, and in daily use, contain from 0.05 per cent to 0.30 per cent of titanic acid. As the percentage of iron in the ore decreases and the amount of gaunge increases, we may look for an increase in the titanic acid present, as it is present in clays to a considerable extent.

The Method of Analysis.

Silica.—One gram of the ore is digested in a porcelain dish in 25 c.c. of strong hydrochloric acid, and the solution filtered into another porcelain dish. The residue is fused, the fusion returned to the dish containing the filtrate from the insoluble residue, and the solution is evaporated to dryness on the steam bath. The residue is moistened with dilute hydrochloric acid (equal parts acid and water), water is added and the solution is brought to a boil and filtered into an 0.5 beaker. The precipitate is washed until free from chlorine, all the washings being caught in the beaker. The washings may appear cloudy, due to the running through of the titanic acid. This is disregarded as it is retained by the precipitation subsequently to be made. The silica on the paper contains a part of the titanic acid and after burning and weighing is volatilized with hydrofluoric and sulphuric acids. The crucible is ignited and weighed, the residue being preserved for the recovery of the titanic acid. The difference between the first and second weights of the crucible is silica.

Manganese, Lime and Magnesia.—A basic acetate precipitation is made in the filtrate from the silica. The titanium present is completely precipitated with the iron and alumina, the writer having found none in the filtrate. The basic acetate precipitate is dissolved by washing with hot dilute hydrochloric acid and hot water. Titanic acid dissolves with difficulty from the paper, the writer having found as high as 0.05 per cent remaining with the filter paper; this is recovered by burning the paper with the impure precipitate of titanic acid subsequently obtained. If the manganese is above 1 per cent in the ore, a second basic acetate precipitation is made in the hydrochloric acid solution of the first precipitate. The manganese lime and magnesia are determined in the filtrate or combined filtrates, as described in "The Methods of the United States Steel Corporation for the Commercial Sampling and Analysis of Iron Ores" (this journal, Vol. VII, page 65).

Alumina.—The hydrochloric acid solution of the basic acetate precipitate is diluted to 300 c.c. and ammonium hydroxide added until a slight permanent precipitate is formed. One and one-half c.c. of strong hydrochloric acid are now added, then 50 c.c. of a 20 per cent sodium thiosulphate solution, followed by 10 c.c. of acetic acid. The solution is boiled 10 minutes, the titanic acid being completely precipitated, accompanied, however, by a part of the alumina and phosphoric acid and a small amount of iron. The amount of alumina varies with the phosphorus and inversely with the acidity, as high as 0.75 per cent having been found in the precipitate from an ore containing ½ per cent of phosphorus and 5 per cent of titanic acid. After allowing a few minutes for the precipitate to settle, the solution is filtered into a No. 5 beaker, and the precipitate washed with a hot 2 per cent acetic acid solution.

To the filtrate 30 c.c. of a 10 per cent solution of ammonium phosphate and 1½ c.c. of strong hydrochloric acid are added at the same time, then 30 c.c. of thiosulphate solution are added. The solution is heated to boiling, at which point 15 c.c. of a 20 per cent solution of ammonium acetate are added, and the solution is boiled 10 minutes. The precipitate of aluminium phosphate is allowed to settle, filtered off and washed slightly with hot water. It is dissolved on the paper with very hot dilute hydrochloric acid into the beaker in which the precipitation was effected. This solution is reserved for a second precipitation after the addition of the alumina recovered from the preliminary titanic acid precipitate as obtained above.

This impure titanic acid precipitate is burned in the crucible containing the residue from the silica volatilization. The contents of the crucible consisting of all the titanic acid, a small quantity of the alumina, part of the phosphorus and some iron are now fused with 2 grams of sodium carbonate. The fusion is disintegrated in 50 c.c. of hot water in a No. 2 beaker and the solution is heated to boiling temperature for 10 minutes, allowed to settle, and filtered through a close filter from the insoluble sodium titanate and ferric oxide into a No. 3 beaker, the residue being washed with a 1 per cent sodium carbonate solution. It may be necessary to refilter the solution as the sodium titanate is liable to run through. To test the completeness of the separation of alumina and titanic acid by the above method the residue on the paper was ignited and again fused with sodium carbonate, digested and filtered as before. No alumina was found in the filtrate in several tests, although the alumina in the filtrate from the first fusion was as high as 2.50 per cent.

The clear filtrate from the sodium titanate is added to the solution of the first aluminium precipitate. To this solution containing all the alumina 10 c.c. of ammonium phosphate solution are added and then ammonium hydroxide is added until a flocculent precipitate is formed, the solution being acid to litmus. One and a half c.c. of strong hydrochloric acid are now added, followed by the addition of 30 c.c. of sodium thiosulphate solution to the clear solution. The solution is heated to boiling, at which point 15 c.c. of ammonium acetate solution and 8 c.c. of acetic acid are added, and the boiling continued 10 minutes. The solution is filtered and the precipitate washed 10 times with hot water, burnt and weighed as aluminium phosphate.

Titanic Acid.—The titanic acid may be determined colorimetrically or gravimetrically. In the former case a sulphuric acid solution of the titanium is required, while in the latter a hydrochloric acid solution is preferable. The filter paper containing the sodium titanate is transferred to the No. 2 beaker in which the fusion was disintegrated, the crucible rinsed with hot acid and water into the beaker and 10 c.c. sulphuric acid

(equal parts acid and water) or strong hydrochloric acid added. On warming all the titanium enters the solution as sulphate or chloride, as the case may be. The solution is filtered from the paper pulp and the titanium determined colorimetrically or gravimetrically in the filtrate.

When the titanic acid is determined by the latter method, the solution of titanium chloride ($TiCl_4$), containing some ferric chloride, is diluted to 300 c.c. in a No. 5 beaker. Ammonium hydroxide is added until a flocculent precipitate is formed and the solution is yet acid to litmus. One and a half c.c. of strong hydrochloric acid are now added, followed by the addition of 30 c.c. thiosulphate solution to the clear solution. The solution is now boiled 10 minutes and the precipitate allowed to settle, filtered and washed 10 times with hot 2 per cent acetic acid solution, burnt and weighed as titanic acid (TiO_2), 0.6005 of which is titanium (Ti).

The titanic acid may be estimated colorimetrically by comparing the solution of titanium sulphate, $Ti(SO_4)_2$, obtained above, or an aliquot part of it, with a standard solution of the sulphate.

To this end the standard titanium sulphate solution may be prepared as follows: One-quarter of a gram of ignited titanic acid (Merck) is fused with 6 grams of sodium carbonate, the fusion disintegrated in 50 c.c. water and the crucible and lid placed therein also. On warming for an hour or more with 100 c.c. dilute sulphuric acid, solution is complete. This solution is transferred to 250 c.c. flask and diluted to the mark with water.

One c.c. of this should contain 1 mg titanic acid. However, the titanic acid obtainable is seldom 100 per cent pure. Its purity may be found and the solution standardized by precipitating 50 c.c. of the solution with thiosulphate in a slightly acid solution, as shown under the gravimetric method.

The color comparison may be made by adding the standard titanium sulphate solution from a burette to a tube containing 5 per cent sulphuric acid and 5 c.c. hydrogen peroxide, the volume being the same as that of the test, until the color matches that of the test solution contained in a tube of the same bore and to which 5 c.c. of hydrogen peroxide have likewise been added. The number of cubic centimeters of standard solution used indicates the titanic acid present. W. F. Hillebrand ("The Analysis of Carbonate and Silicate Rocks," Bulletin 422 of United States Geological Survey) states that some hydrogen peroxide contains fluorine, which bleaches the yellow color, and gives method for testing for it.

Phosphorus and Sulphur.—These elements are determined as described in "The Methods of the United States Steel Corporation for the Commercial Sampling and Analysis of Iron Ores," previously mentioned. However, in the determination of sulphur in an ore containing titanic acid, sodium nitrate should be used in the fusion of the ore in place of the more common potassium salt as the potassium titanate is soluble.

The alumina and titanic acid in the Iron Mountain Standard Ore of the United States Steel Corporation and in the Crescent Standard Ore of the Bureau of Standards were determined by the foregoing method with the following results:

	Alumina.		Titanic Acid.	
Iron Mountain	1.25	1.26%	0.10	0.10%
Crescent	1.00	1.01	0.07	0.07

A test was also made adding titanium chloride solution to the solution of the foregoing ores and determining alumina and titanic acid in the mixture. One-half gram of ignited chemically pure (?) titanic acid was fused with sodium carbonate, disintegrated in hot water and dissolved in 100 c.c. strong hydrochloric acid. The solution was transferred to a flask and made up to 500 c.c. and the titanic acid determined on 50 c.c. portions.

Alumina and titanic acid were also determined in the mixture of 50 c.c. of the above solution of titanium chloride with the solution of one gram of standard ore. Results were as follows:

	Al_2O_3 calculated from $AlPO_4$	TiO_2 as weighed	TiO_2 in Ore	TiO_2
	grams.	grams.	grams.	grams.
Precipitated by NH_4OH	....	.0435	....	....
Fe_2O_3 present	....	.0007	....	....
Difference	....	....	....	.0478
Precipitated by $Na_2S_2O_3$	....	....	....	.0478
Precipitated by $Na_2S_2O_3$	....	....	....	.0479
With Sol. of 1 gram Iron Mountain Ore	.0129	.0488	.0010	.0478
With Sol. of 1 gram Iron Mountain Ore	.0130	.0488	.0010	.0478
With Sol. of 1 gram Crescent Ore	.0101	.0486	.0007	.0479
With Sol. of 1 gram Crescent Ore	.0103	.0488	.0007	.0481

The Bureau of Standards report on their Crescent Standard Ore, Alumina 1.01 per cent, Titanic Acid .07 per cent.

Laboratory of Duquesne Steel Works, Duquesne, Pa.

The Equilibrium of the System Consisting of Calcium Carbide, Calcium Cyanamide Carbon and Nitrogen.

BY M. DE KAY THOMPSON AND ROBERT H. LOMBARD.*

Since the discovery by Frank and Carol[1] that pure nitrogen is absorbed by impure calcium carbide at high temperature according to the reversible reaction:

$$CaC_2 + N_2 \rightleftarrows CaCN_2 + C,$$

calcium carbide has been employed on a commercial scale for the fixation of atmospheric nitrogen. This method yields four times as much nitrogen for a given amount of power as the direct oxidation in an electric arc. Calcium cyanamide can be used directly as a fertilizer or it may be the starting point for the manufacture of other nitrogen compounds. In consequence of the importance of this reaction, we were led to undertake the determination of the equilibrium pressure of the nitrogen

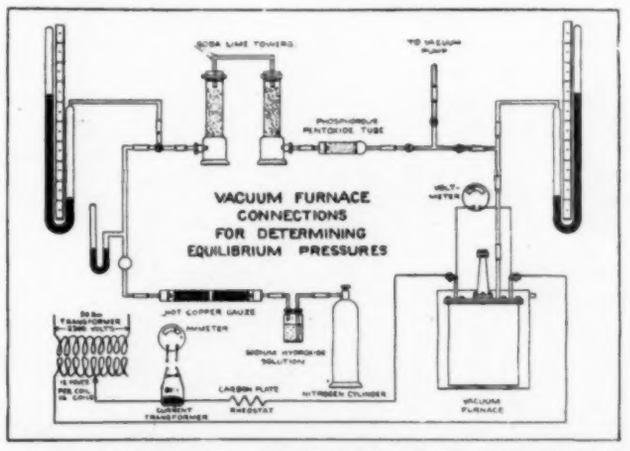

FIG. I.—ARRANGEMENT OF APPARATUS FOR MEASURING EQUILIBRIUM PRESSURE.

in the above reaction for a number of different temperatures. In this system there are three components and four phases; consequently, according to the phase rule there will be one degree of freedom, or for every temperature a corresponding pressure at which equilibrium will exist.

The method of carrying out this investigation was to heat a graphite crucible containing graphite, calcium carbide and calcium cyanamide in an Arsem vacuum furnace[2] in an atmosphere of nitrogen. The heating current was taken from a transformer in steps of 12 volts, and fine adjustment of the current was obtained by a carbon-plate rheostat. The pressure was indicated by a mercury manometer, one arm of which was connected with the furnace, the other was evacuated and sealed off.

The arrangement of the apparatus is shown in Fig. 1. It

*The following research was carried out under a grant from the Rumford Fund of the American Academy of Arts and Sciences. Grateful acknowledgment is hereby made to the trustees of this fund.

[1] *Z. f.angew. Chem.* 19,853 (1906).

[2] *Trans. Am. Electroch. Soc.* 9,163 (1906).

was intended to measure the temperature of the crucible by means of a thermoelectric junction entering the furnace through the tower projecting above the water in which the furnace is immersed, and two or three such runs were made, in which the wires of the couple were insulated from each other by different kinds of tubes. One wire was covered with a tube 1 mm in diameter, and this tube and the other wire were placed in a larger tube sealed at the end which covered the junction.

These tubes were long enough to reach up into the tower when their lower end was resting in the crucible. The hot end of the tube surrounding the wires of the thermoelectric couple was covered with a short graphite tube to protect it from the material in the crucible.

No tubes that were available, however, would stand a temperature above 1200° C. Even Berlin porcelain was spoiled after a few hours' heating. Carbon seemed to have penetrated the whole mass of the porcelain where it was surrounded by the graphite spiral heater, and as much of the couple as was heated was also spoiled.

It was, therefore, necessary to give up the direct measurement by the thermocouple and use a Wanner optical pyrometer. The instrument used in this investigation had just been calibrated by the Bureau of Standards, with results that were not materially different from the calibration furnished by the makers. The amyl acetate lamp was not constant, however, and, therefore, adjustment of the current in the small electric lamp of the Wanner pyrometer was made as follows:

A furnace, shown in Fig. 2, was made by wrapping platinum foil ¼ in. wide and 0.001 in. thick about a Royal Meissen porcelain tube of 2.54 cm inside diameter. A cylindrical piece of graphite was placed in the furnace, and a small porcelain tube was passed through the larger one and through a hole in the graphite. The smaller tube was to hold the thermoelectric couple, the junction of which was in the same plane as one of the faces of the carbon. The temperature of this face of the carbon was, therefore, given directly by the thermoelectric couple.

In order to adjust the current in the Wanner pyrometer the reading of the Wanner was set to agree with that of the couple, a piece of glass cut from the same plate as that in the tower of the vacuum furnace was placed in the groove in the pyrometer provided for holding the smoked glass sometimes used for increasing the range of the instrument, and the pyrometer was sighted on the graphite cylinder. The current was then adjusted until the two fields in the pyrometer had the same appearance. The small furnace was kept heated during each run, and before measuring the temperature of the vacuum furnace a comparison was always made with the thermoelectric couple.

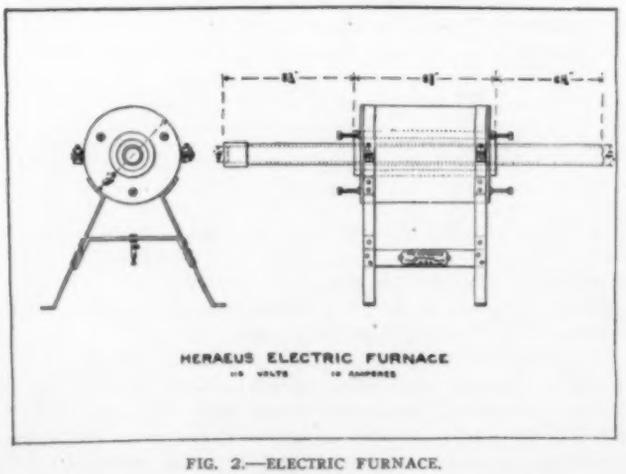

FIG. 2.—ELECTRIC FURNACE.

It was found that by this means the current in the lamp as adjusted from day to day was much more constant than when the amyl acetate lamp was used as a standard, but it will be seen from the tables below that the current was not absolutely constant. This must have been due to a variation in the electric lamp itself. The following table shows the effect of a change of the current in the lamp on the apparent temperature as measured by the pyrometer. The temperature of the body measured was held constant in the vacuum furnace. The current is given in arbitrary units equal approximately to tenths of an ampere.

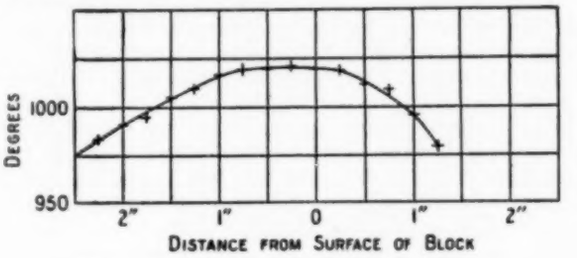

FIG. 3.—NON-UNIFORMITY OF TEMPERATURE.

TABLE I.

Current in Wanner pyrometer.	Temperature.
6.0	1304
6.1	1295
6.2	1282
6.3	1263
6.4	1263
6.5	1241
6.6	1226

The current could not be set better than 0.1 of a unit, corresponding on the average to 10°.

In order to see how the temperature varied in the auxiliary furnace the temperature was taken with the junction at different distances from the surface of the carbon block, which was placed near the center of the tube. The results are given in Fig. 3, which shows that no appreciable error would be introduced if the junction had not been exactly in the same plane as the surface of the graphite block.

The calcium carbide used in the following experiments was all made at one time in an arc furnace from Merck's lime and turnings from Acheson graphite electrodes. It was analyzed by the loss in weight method and found 78¼ per cent pure, having been ground up and passed through a sieve with 36 meshes to the linear inch before the analyses were made.

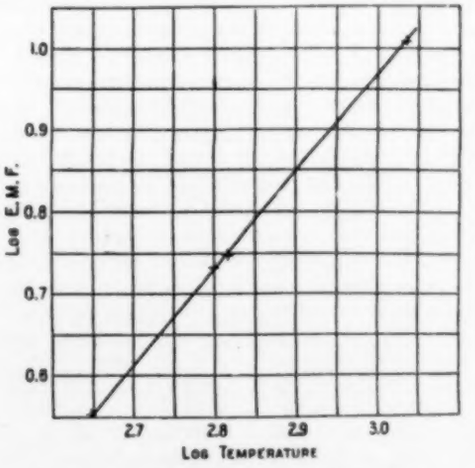

FIG. 4.—CALIBRATION OF THERMOCOUPLE.

The method of carrying out the experiments was as follows: The crucible was filled nearly to the top with the carbide, was

covered with a graphite lid with a hole in it, and then placed in the furnace. The furnace was pumped out and the charge heated to the temperature at which the experiment was to be made (or higher) until all gases were driven off. Nitrogen, made by the Linde process and 90 per cent pure, was let into the furnace after passing it over hot copper, soda lime and phosphorus pentoxide.

After allowing the nitrogen to enter the furnace until the pressure was 2 cm or 3 cm, it was pumped out to about 1 mm or 2 mm. This was repeated once or twice to remove all other gases. The furnace was filled with nitrogen to a pressure that was certainly greater than the equilibrium pressure. The furnace was generally hot when filled. The furnace was often filled in the afternoon and the run started on the following morning. On heating with an excess of nitrogen some of it would be absorbed, producing calcium cyanamide and carbon for the carbide, so that all three solid phases were then present. After equilibrium had been reached from this side, nitrogen was pumped out, and the equilibrium was approached from the other side. The mean of the two results was taken as the best value of the equilibrium obtainable.

Experimental Data.

A Siemens & Halske millivoltmeter of 471 ohms resistance was used for measuring the temperature with a platinum, platinum-rhodium junction. The millivoltmeter was calibrated and the following table contains the corrected value of the scale reading with the corresponding temperature:

TABLE 2.—CALIBRATION OF THERMOELECTRIC JUNCTION.

	Temperature Cent. of melting point.	Millivolts.	Log of temperature.	Log of millivolts.
Sulphur	447.7	3.56	2,6481	0.5515
Antimony	630.7	5.38	2.7998	0.7307
Aluminium	656.	5.59	2.8169	0.7474
Copper	1083.	10.19	3.0346	1.0081

The logarithms of the temperatures and pressures are seen from Fig. 4 to lie on a straight line.

The pressures given in the following tables are millimeters of mercury and the temperatures in centigrade degrees. The numbers of the experiments are those recorded in the laboratory notebook. These tables contain only an abbreviated record of the experiments. Under the heading "Kilowatts" is given the product of current and amperes divided by 1000, not taking into account the power-factor of the furnace.

EXPERIMENT 4.

The following experiment was carried out before the method of standardizing the Wanner pyrometer described above had been adopted. Temperature measurements of the charge were, therefore, made with different values of the current in the lamp of the Wanner pyrometer, and the correct value, with its corresponding temperature, was determined subsequently from Table 1.

	Time.	Kilowatts.	Pressure.
April 28.	1:23 p. m.	8.36	317.8
	1:50 " "	8.26	276.3

Some nitrogen was pumped out in order not to use up all the carbide.

	1:52 p. m.	8.52	264.0
	4:45 " "	8.52	267.4
	Time.	Kilowatts.	Pressure.
April 29.	12:35 p. m.	8.52	267.8
	2:22 " "	8.53	270.0

Here the pressure had become nearly constant, so nitrogen was admitted.

	2:25 p. m.	8.48	277.0
	4:45 " "	8.52	273.3

The equilibrium pressure is, therefore, between 270 mm and 273 mm, or 271.5 mm of mercury. The temperature, determined as explained above, was 1263° C.

EXPERIMENT 6.

A fresh charge of 33.7 grams of carbide was used in the following experiment:

	Time.	Kilowatts.	Pressure.
May 11.	2:55 p. m.	7.65	281.7
	4:05 " "	7.66	224.0
	4:37 " "	7.66	223.6

The pressure had become nearly constant, so nitrogen was admitted.

	4:45 p. m.	7.66	226.3
	5:10 " "	7.66	225.1
May 12.	12:40 " "	7.70	218.5
	1:00 " "	7.00	222.7
	2:22 " "	7.58	223.0

Nitrogen was again pumped out.

	2:23 p. m.	7.58	214.1
	4:30 " "	7.52	224.7
May 13.	1:45 " "	7.56	224.6
	2:45 " "	7.61	223.5

The pressure had become nearly constant at 224 mm, so nitrogen was admitted.

	Time.	Kilowatts.	Pressure.
	2:55 p. m.	7.61	236.0
	5:05 " "	7.40	224.7

The mean temperature was 1223 with the current in the lamp of the Wanner pyrometer 6.4 units. The equilibrium pressure was determined twice from each direction and was found to be 224 mm.

EXPERIMENT 7.

The following experiment was made with the same charge as in 6:

	Time.	Kilowatts.	Pressure.
May 17.	2:35 p. m.	8.98	275.3
	3:45 " "	8.98	282.9

The pressure was increasing very slowly, possibly all calcium cyanamide having been decomposed. Then free nitrogen was admitted.

	3:50 p. m.	8.98	316.5
	4:55 " "	8.98	304.2
May 18.	1:30 " "	8.92	305.6
	3:00 " "	8.78	305.1

The pressure had become nearly constant. Nitrogen was, therefore admitted.

	3:02 p. m.	8.78	329.2
	4:45 " "	8.71	311.8
	5:00 " "	8.71	313.0
May 19.	12.30 " "	8.78	312.5
	1:13 " "	8.71	312.9

The pressure was nearly constant.
Some nitrogen was then pumped out.

	Time.	Kilowatts.	Pressure.
	1:18 p. m.	8.71	293.8
	3:35 " "	8.71	307.0

The pressure had become nearly constant. Some nitrogen was, therefore, admitted.

	3:38 p. m.	8.71	317.4
	4:20 " "	8.71	313.0

Absorption was taking place very slowly. In order to see whether 313 or 305 was nearer the true value, nitrogen was pumped out.

	4:34 p. m.	8.71	309.0
	4:55 " "	8.71	310.3

The results of this experiment are somewhat inconsistent, as the pressure was decreasing at 305 mm and increasing at 310 mm. The mean of these is 308 mm, and the mean temperature was 1297° C. The current in the lamp of the Wanner pyrometer was from 6.3 to 6.5 units.

EXPERIMENT 8.

	Time.	Kilowatts.	Pressure.	Current in Wanner pyrometer.	Temperature.
June 14.	1:55 p. m.	9.86	444.0	5.80	1371
	2:15 " "	9.86	384.8	...	....
	2:45 " "	9.69	373.8	5.83	1379
	3:15 " "	9.73	375.3	5.88	1373
	3:45 " "	9.73	375.4	5.82	1371
	4:45 " "	9.65	376.1	5.80	1377
June 15.	8:45 a. m.	9.67	....	...	....
	9:15 " "	9.71	374.2	...	....
	10:30 " "	9.68	376.5	5.80	1380
	Nitrogen was pumped out.				
	11:13 a. m.	9.64	366.6	...	....
	11:30 " "	9.65	370.2	5.88	1374
	12:30 " "	9.62	373.4	...	....
	1:30 p. m.	9.65	377.3	5.84	1377
	4:30 " "	9.55	379.3	...	....

It is seen that the pressure decreased until it became constant at about 376 millimeters, and after pumping out to 367 it increased to 379. The average mean is 378 millimeters and the average temperature 1378. The interior of the furnace after these runs was found covered with a thick white deposit.

The charge in the crucible in each case gave tests for carbide and calcium cyanamide. The latter was tested for by adding ammonia and silver nitrate to the aqueous solution. A yellow precipitate of silver cyanamide showed the presence of calcium cyanamide. The white powder taken from the walls of the furnace also gave a yellow precipitate of silver cyanamide on adding ammonia and silver nitrate to a solution of this substance.

EXPERIMENT 9.

In the following run an attempt was made to measure an equilibrium at about 1440. It was not successful, however, as will be seen from the following results:

Time.	Kilowatts.	Pressure.	Current in Wanner pyrometer.	Temperature.
10:15 a. m.	10.6	....	...	....
10:20 " "	10.88	650.0	5.75	1433
10:30 " "	10.94	587.0	...	....
11:30 " "	10.94	513.3	...	....
12:55 p, m.	10.94	514.0	5.80	1420
Some nitrogen pumped out.				
1:00 p. m.	10.94	458.0	...	....
1:15 " "	10.94	468.0	...	....
2:00 " "	10.94	469.0	...	....
Some nitrogen pumped out.				
2:05 p. m.	10.94	460.0	...	....
2:45 " "	10.94	461.0	...	....
More nitrogen pumped out.				
2:50 p. m.	10.94	427.0	...	....
3:45 " "	10.94	432.7	5.92	1448

It is evident that though the reaction goes in both directions at this temperature, it is so slow that it is difficult to tell whether an equilibrium has been reached or not. The reason for this may have been that the charge had become very hard and could not be dug out of the crucible and appeared as though it had been somewhat fused together. This would make it difficult for the nitrogen to penetrate its entire mass. The average temperature of this run was 1437° C. A later attempt at 1448° was more successful and is given in Experiment 15.

(To be concluded.)

Zinc Ore Dressing in Colorado--II.

By H. C. Parmelee.

The Wellington Mines Company.

The property of the Wellington Mines Company is in Summit County, Colorado, about two and one-half miles up French Gulch from the town of Breckenridge. It comprises about 150 acres of mineral land and a concentrating mill of 80 tons daily capacity. The history of the mine is similar to that of many others in the region. Located over 20 years ago it yielded some carbonate ore from surface deposits, but deeper working developed the complex zinc-lead-iron sulphides which are now characteristic of the district, and which have remained undeveloped while more easily treated ores have been sought. It is mainly in the successful milling of the mixed sulphides that the Wellington now lays claim to attention.

The nature of the crude ore is shown in the following tabulation of analyses of several samples. The lime and silver given in some of the samples may be taken as typical of those from which they are omitted.

WELLINGTON CRUDE ORE.

Zn	%	17.4	17.1	15.5	15.3
Pb	%	9.2	9.0	7.6	7.7
Fe	%	20.6	20.5	19.8	28.0
SiO_2	%	18.4	22.2	20.1	....
CaO	%	...	...	...	1.2
Ag.	oz.	3.56	3.40	....	....

At present the Wellington mill uses a system of wet dressing only, but is preparing to install roasters and magnetic separators to treat a low grade zinc-iron middling which is now accumulating.

Jigs are used, commencing concentration at 4 + 6 mesh and finishing with slime. A peculiar feature in the construction of the Wellington mill is that the rolls are set in the upper part of the building. At first sight this plan would be condemned, but an inspection of the flow sheet given herewith will probably bring out an advantage, viz., that the elevators handle only coarse material from which the fine has been screened, and therefore operate easily, giving no trouble on account of the load sticking in the buckets and requiring a water spray for its complete release. The work described herewith represents merely the present state of progress toward a finished system which the present management has planned.

Crushing and Screening.

The ore is delivered by electric tramway to crude ore bins of 80 tons capacity. Passing over a grizzly (1-in. slots), the oversize is fed to a 10-in. x 15-in. Blake crusher, reducing the ore to 1¼-in. size. Crushed ore and undersize of the grizzly are combined and elevated by (No. 1) 12-in. B. and B. elevator to crushed ore bins of 80 tons capacity. A Challenge feeder discharges ore from these bins to (No. 2) 10-in. B. and B. elevator (where water is added), which delivers to a trommel fitted with ⅜-in. punched screen. The oversize passes to No. 1 14-in. x 27-in. horizontal rolls and thence back to (No. 2) elevator. The undersize is delivered to the screen line of three trommels fitted with 4-mesh, 6-mesh and 12-mesh wire screen of No. 12 gage, 14 gage and 18 gage respectively.

The oversize of the 4-mesh trommel is delivered by (No. 3) 10-in. B. and B. elevator to No. 2 14-in. x 27-in. horizontal rolls, and thence back to the screen line. The undersize of the 4-mesh trommel passes to the 6-mesh trommel, the oversize of the latter (being through 4-mesh and on 6-mesh) is sent to jigs Nos. 1 and 2. The undersize of the 6-mesh trommel passes to the 12-mesh, the oversize of which (being through 6-mesh and on 12-mesh), passes to jigs Nos. 3 and 4. The undersize of the 12-mesh trommel is laundered to a thickening cone, preliminary to classification for treatment on Nos. 5 and 6 jigs, and on the tables.

Jigging.

The jig equipment consists of three double 6-compartment Harz jigs, or six in all.

The details of jigging given in the present article apply to general practice which, it will be understood, may be changed occasionally as the mill feed varies in mineral composition. All compartments of all jigs make hutch products, and from some compartments an overflow discharge is also taken off through the side gates. The jig products are lead concentrate, shipped to the lead smelter; low-grade zinc-lead-iron middling, stored for future magnetic separation; middling for regrinding and further concentration; high-grade zinc-iron middling, shipped to pigment works; and zinc concentrate, shipped to zinc smelter.

The source of these various jig products can be understood better from the following diagram of the jigs, in which hutch and gate-and-dam products are indicated.

The coarse jigs are represented at the top of the diagram, and the finer below.

The flow of ore is from left to right. The terms used in the

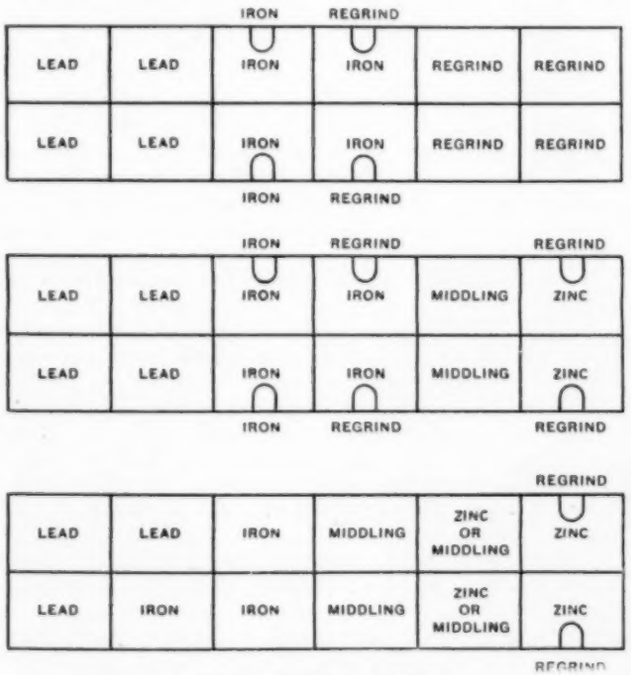

FIG. 1.—DIAGRAM OF JIGS.

diagram, and their meanings are, lead, galena concentrate; iron, zinc-lead-iron middling for magnetic separation; regrind, middling which is reground and further concentrated; middling, high-grade zinc-iron middling used for pigment; zinc, zinc concentrate.

DIAGRAM OF JIG PRODUCTS.

The following tabulation gives some details of the jigging practice at the Wellington mill:

MESH OF JIG SCREEN.

Jig. No.	—Compartment Number— 1	2	3	4	5	6
1.....	4	5	6	6	7	8
2.....	4	5	6	6	7	8
3.....	6	7	7	7	7	7
4.....	6	7	7	7	7	7
5.....	10	12	10	10	10	10
6.....	10	12	10	10	12	12

The gage of wire used in the various screens is as follows: 4-mesh, No. 14; 5-mesh, No. 15; 6-mesh, No. 16; 7-mesh, No. 17; 8-mesh, No. 18; 10-mesh, No. 19; 12-mesh, No. 20.

SPEED (R.P.M.) AND LENGTH OF STROKE (INCHES) OF JIG PLUNGERS

Jig No.	r.p.m.	—Compartment Number— 1	2	3	4	5	6
1	175	⅞	5⅛	1	¾	¾	1
2	175	⅞	5⅛	1	¾	¾	1
3	235	5⅛	½	¾	½	½	¾
4	235	5⅛	½	5⅛	½	½	¾
5	272	5⅛	½	5⅛	½	5⅛	¾
6	294	½	⅜	½	⅜	⅜	½

In bedding the jigs, clean galena crushed to ½-in. mesh is used for the first two compartments of the two coarse jigs. The finer jigs are bedded, as required, with the lead or iron concentrates of the coarse jigs.

Classification.

As stated above, the undersize of the last (12-mesh) trommel is classified into suitable products for the fine (Nos. 5 and 6) jigs and the tables. The hydraulic classifier is one designed by general manager Robert M. Henderson, and is somewhat similar in outline and action to the Richards pulsator classifier

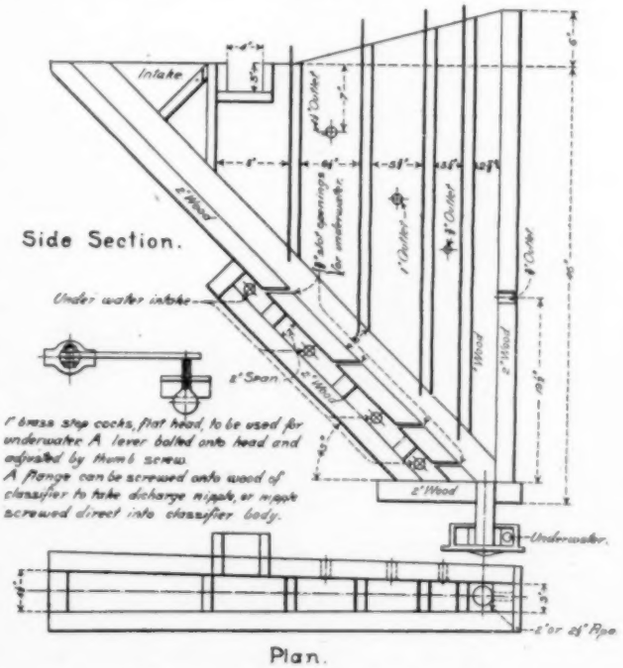

FIG. 2.—HENDERSON'S CLASSIFIER.

although the hydraulic water is without pulsations. As illustrated herewith the box has the general outline of an inverted right angled triangle, and is divided vertically into compartments decreasing in size from the first to the fifth. The feed flows down the inclined bottom of the box, and as it passes beneath the various compartments is hydraulically classified by water introduced at the proper points. The first compartment receives no hydraulic stream and gives an overflow of the finest material. The second, third and fourth compartments yield increasingly coarser products. The fifth compartment gives two products, one from a spigot placed in the descending line of spigots from the other compartments, and the other from a vortex classifier placed at the bottom of the compartment. The 5-compartment classifier thus yields six products. The appearance of the concentrating tables attests the excellence of the classifier.

The disposition of the classified products is as follows: Fifth compartment (spigot and vortex), to Nos. 5 and 6 jigs; the other four compartments to concentrating tables.

Table Concentration.

The table equipment consists of three No. 4 and one No. 5 Wilfley tables, and one Card. The Wilfley tables treat pulp

from the first four compartments of the classifier, and the Card receives thickened slime from the cone system. The details of table operation are tabulated below.

No.	Table	Feed	Strokes per min.	Length of Stroke
1	Wilfley	Coarse	240	15/16 in.
2	"	Medium	240	⅞ in.
3	"	"	280	1 in.
4	"	Fine	280	¾ in.
5	Card	Slime	290	⅜ in.

Three shipping products are recovered from each table, viz., lead concentrate, high-grade zinc-iron middling and zinc concentrate. The iron is divided between the lead and zinc to make suitable shipping products according to smelter contracts. Tailings from tables, jigs, and the overflow from the cone system all go to waste. They are automatically sampled by a Scobey tailing sampler taking a sample every 2 minutes. The accumulation is assayed every two days.

Products.

The following assays are typical of the products now being made.

GENERAL ZINC CONCENTRATE

Au	oz.	0.02	0.015	0.02
Ag	oz.	3.00	2.90	2.20
Pb	%	1.8	Trace	1.7
Fe	%	16.4	16.1	15.3
Zn	%	35.2	39.6	37.5
SiO_2	%	7.0	6.0	6.4
Cu	%	0.26	..	0.3
S	%	28.6	25.9	31.0
CaO	%	0.6	1.2	...

The above assays represent the mixed jig and table concentrates just as shipped. The average of the jig zinc is about the same as that of table zinc, although different machines in both classes vary in the quality of their products. The order of the jigs in the quality of zinc concentrate made is 3, 4, 5, 6, 1, 2 (No. 1, coarse and No. 6, fine). The order of the tables in the quality of their zinc concentrate is 3, 2, 4, 5, 1 (No. 1. coarse and No. 5, slime), varying from 43 to 35% zinc respectively.

The mixed jig and table galena concentrate as shipped, assays as follows:

GENERAL LEAD CONCENTRATE

Au	oz.	0.03	0.03
Ag	oz.	11.20	10.60
Pb	%	46.4	44.8
Fe	%	15.9	17.0
Zn	%	...	5.4
SiO_2	%	2.0	2.5

The zinc-iron middlings are of two grades; one, a high-grade middling shipped to pigment works, and the other, a low-grade middling now being saved for roasting and magnetic separation.

MIDDLINGS

		High-grade	Low-grade
Zn	%	28.3	13.2
Fe	%	24.3	32.5
Pb	%	3.1	5.2

The tailings, combined as described before, assay as follows:

GENERAL TAILING

Zn	%	9.4	8.5	10.7	9.0	9.4	8.7
Pb	%	2.0	1.9	2.2	1.2	1.3	1.9
Fe	%	..	..	..	..	..	9.8
CaO	%	3.0	2.6	..	..	..	..
SiO_2	%	..	..	..	..	..	47.3

Power, Water and Labor.

The mill is electrically operated. Current is supplied by the Central Colorado Power Company at 13,000 volts, which is stepped down to 440 volts at the mill transformer house. Two motors suffice for the operation of the mill machinery. One 75-hp motor drives the crusher, rolls, elevators, screens, jigs and water pump; and one 10-hp motor operates the tables, tailing sampler and slime pump.

Water is secured from springs and conducted to the mill by flume, and raised by a centrifugal pump to a tank placed in the upper part of the building. Arrangements are also made to reuse a part of the mill water when the natural supply is short. The jig tailings can be dewatered and the clear water pumped back for further use.

Four men, in addition to the foremen or shift boss, are required for each of two shifts. As crushing is carried on for but two shifts, one man is dispensed with on the third shift.

Proposed Improvements.

It is intended immediately to install additional jigs and tables. Instead of directly regrinding the oversize from the 4-mesh trommel, it will be jigged first, as it contains a great deal of clean mineral which does not require regrinding. Also, instead of returning the reground jig middling to the screen line at the 6-mesh trommel, it will be sized and jigged separately. An additional Card table will be installed for slime treatment, as the present slime feed is too heavy for one table, and another Wilfley will be added to treat the reground middling mentioned.

When a sufficiently large quantity of zinc-iron middling has accumulated to warrant the erection of a magnetic separation plant, it will be installed. In all probability the management will favor the multiple hearth type of roaster, but the type of magnetic separator has not been decided upon. Additional table equipment also will be provided to treat the zinc-lead tailing from the magnetic separators, as there is sufficient lead present to warrant this step. The magnetic iron removed will be without value.

Following is a condensed statement of the Wellington mill practice:

Crude ore by electric tram to
1 Bins of 80 tons capacity, over grizzly (1-in. slots) to
2 10 x 15 Blake crusher reducing to 1¼ in.
Undersize of grizzly and product of crusher to
3 12-in. B. and B. elevator to
4 Bins of 80 tons capacity, by Challenge feeder to
5 10-in. B. and B. elevator to
6 ⅜-in. punched screen trommel; oversize to 7; undersize to 8.
7 14 x 27 horizontal rolls, back to 5.
8 4-mesh wire screen trommel; oversize to 9; undersize to 11.
9 10-in. B. and B. elevator to
10 14 x 27 horizontal rolls, back to 8.
11 6-mesh wire screen trommel; oversize to 13; undersize to
12 12-mesh wire screen trommel oversize to 14; undersize to 15.
13 Nos. 1 and 2 jigs.
14 Nos. 3 and 4 jigs.
15 Thickening cone; underflow to 16; overflow to 21.
16 5-compartment classifier; 5th, compartment to 17; first four compartments to 20.
17 Nos. 5 and 6 jigs.
Jig middling or regrinding to
18 10-in. B. and B. elevator to
19 12 x 20 horizontal rolls, back to 11.
20 Four Wilfley tables.
21 Thickening cone; overflow to 22; underflow to 23.
22 Thickening cone; overflow to waste; underflow to 23.
23 Card table.

Silver Production in Mexico.—The July production of the Rio Plata Mining Company, Chihuahua, Mex., amounted to 82,000 oz. of silver. This is the largest monthly production on record, the best previous showing having been made in January, when 71,164 oz. were produced. Last month's shipment of bullion to Monterey brought $40,340.

Modified Cyanide Process.

Reference has already been made in our abstracts of recent chemical and metallurgical patents to improvements in the cyanide process, due to Mr. JOHN COLLINS CLANCY, chief metallurgist of the Moore Filter Company, of New York City.

In view of the great interest which this invention is attracting, a summary of the process will be welcome.

The process will be found particularly interesting from an electrometallurgical standpoint. Calcium cyanamide, which plays a very important part in Mr. Clancy's process, is an electric-furnace product obtained by the action of nitrogen gas (obtained from air, for instance, by liquefaction) upon calcium carbide, the latter being also an electric-furnace product. There are various calcium cyanamide plants in operation in Europe and one, that of the American Cyanamide Company, at Niagara Falls, Ontario, Canada. While heretofore calcium cyanamide has been used only as a fertilizer, Mr. Clancy's invention opens a new and important field for it in the metallurgy of gold and silver.

But the relation of the Clancy process to electrometallurgy is still more intimate, since, as will be seen, electrolysis plays an important part in the process.

The following quotations are taken from a foreign patent specification of Mr. Clancy:

Chief Principles.

"I have discovered that a cyanogen-bearing compound which is not a solvent of the precious metals can be made a solvent of the same by the addition of an amidine or amide compound in the presence of an electric current. As a result of this discovery I am able to use cyanogen compounds, heretofore not available in the cyanide process, and also I am able to regenerate spent cyanide solutions, and I am also able to use in the cyanide process oxidizing agents without loss of available cyanide.

"I have also discovered that when the pulverized ore is converted into a pulp by mixing the said ore with a substantially non-acid solution of a thiocyanate containing a halogen salt, and electrolyzing this mixture, then the precious metals only will be dissolved to the substantial exclusion of the baser metals, and that the above solution may be used with advantage in conjunction with the ordinary cyanide solution, and that this process may be successfully applied to either rebellious or non-rebellious ore without preliminary roasting, even though such ores contain reducing agents or tellurium or both.

Use of Cyanamide with Electrolysis.

"In the practice of my invention I may use the crude cyanamide of commerce, its isomerides and polymerides, as a solvent for the precious metals and other metals contained in ores; or I may use a soluble cyanamide in conjunction with the cyanide process in the treatment of ores, and as a means of regenerating cyanide solution or non-available cyanogen-bearing solution.

"When a soluble amidine or amide compound (such, for example, as dicyandiamidine, urea, guanidine, guanidyl-gluanidine, guanidine carbonate, formamide, oxamide, cyanamide, dicyanamide, or the various polymeric and isomeric modifications of the last-mentioned compounds) is added to a cyanogen-bearing solution and the mixture electrolyzed in contact with ore, the consumption of cyanide is very strikingly reduced; and also solutions containing cyanates, before, after or during the treatment of ore (together with ferrocyanides, ferri-cyanides, thiocyanates, or other such non-available cyanogen compounds formed in the treatment of ores) may be converted into compounds which readily dissolve the precious metals contained in ores; and most remarkable is the regeneration of cyanide from cyanates, such as alkaline cyanates, isocyanates and the various isomeric and polymeric compounds, or the oxygen derivatives of cyanogen, their isomerides and polymerides.

"I have described the addition of a soluble amidine or amide compound, which may also include any of the above mentioned compounds; but I use preferably, when working my process, a soluble cyanamide (such, for example, as calcium cyanamide, as it is at present the cheapest source of an amidine or amide compound). A solution of calcium cyanamide, or its isomerides and polymerides, when subjected to electrolysis, is, I have discovered, capable of dissolving the precious metals, and other metals, without any other admixture of cyanogen-bearing material. From cyanamide all the amide or amidogen compounds I have mentioned are very easily prepared. For instance, by the action of sulphuric acid or hydrochloric acid upon cyanamide, water is absorbed and it becomes urea. B_2S converts it into thio-urea. NH_3 converts it into guanidine, while substituted guanidines are produced upon introducing the hydrochlorides or primary amines; and numerous other amide compounds may be prepared by simply inexpensive chemical treatment of cyanamide. It will, therefore, be obvious that my claim for a soluble amidine or amide compound includes all the polymeric and isomeric modifications and transpositions of soluble cyanamides.

"To show the action of these amide compounds I may take, for example, urea (carbamide) and add this to a solution of a cyanate (such, for example, as potassium cyanate) and electrolyze this mixture between inert electrodes. After a few minutes the said mixture will be transformed into one which will dissolve the precious metal in alkaline solution. It is well known that cyanates have absolutely no dissolving effect upon the precious metals, and that the formation of cyanate in the cyanide solution represents the chief source of loss of cyanide in the cyanide process, since when cyanates are allowed to stand for any considerable time, or are retained in solution, they are converted into ammonia and potassium carbonates and are transposed by the lime used in the cyanide process into insoluble carbonates, or by the action of sulphuric acid in the ore into sulphates, so that the original cyanide finds itself eventually in the residue dumps in the form of calcium sulphates or insoluble carbonates. Any oxidation means, when used in the cyanide solution to hasten the dissolution of the precious metals, increases the cyanide consumption, due to the formation of cyanate, which is often very great; and up to the present no means for regeneration or recovery of cyanide from cyanate in aqueous solutions has ever been discovered, so far as I am aware; but by my discovery that a soluble amidine or amide compound (such, for example, as calcium cyanamide) added to the cyanide-bearing solution, in conjunction with the electrolysis of said solution, opens up a cheap way whereby oxidation means other than atmospheric oxygen (such as treatment of cyanide-bearing solutions with oxidizing agents and soluble halogen compounds, or other oxidation means) may be successfully employed for readily dissolving and extracting precious metals from refractory ores, such as tellurides, arsenides, sulphides and other ores containing reducing agents. In general, this process may be successfully applied to either rebellious or non-rebellious ores without preliminary roasting, even though such ores contain the refractory compounds mentioned.

Apparatus.

"The apparatus for carrying my process into effect is simply the ordinary agitating tank furnished with electrodes spaced about from 1½ in. to 2 in. apart. These electrodes may be made of carbon, or one of iron and another or carbon; that is to say, the positive electrode undergoes no deterioration, as only nascent hydrogen is produced at the said electrode; therefore, iron answers the purpose. The negative electrode or anode is made preferably of a hard graphite or other such inert material.

"The circulation caused by the agitation keeps the whole mixture constantly circulating between the said electrodes. This circulation is maintained for a period of from 8 to 12 hours to obtain the desired result, which is described in the

examples. The said agitating tank with the electrodes is equivalent to the electrolyzer described in the examples.

Use of Halogen Compounds.

"Different ores require variations in the composition of the solution and in the current. For example, in treating ores containing tellurides or arsenides we may add a soluble halogen compound to the cyanamide treatment solution, or to the cyanogen-bearing solution, or to the non-available cyanogen-bearing solution, in the manner shown in the examples following.

"The function of a halogen compound—such, for example, as potassium iodide, when added to the cyanogen-bearing solution—is, that during electrolysis, the iodine liberated at the anode acts as an oxidizing agent. It is clear, therefore, that the presence of a halogen compound, such, for example, as potassium iodide, in said solutions, insures complete absorption of any nascent oxygen which might escape without doing oxidation work. The halogens also form addition compounds with cyanamide, these addition compounds in themselves acting as oxidizing agents.

"It is, therefore, obvious that in any of the examples given the function of the halogen is analogous.

Examples.

"In the following examples I use a solution of a soluble cyanamide alone or in conjunction with the cyanide solution, or in conjunction with a non-available cyanogen-bearing solution. By non-available cyaogen-bearing solution I mean one that contains cyanogen in a different combination from that in which it exists in what is known as simple alkaline cyanides. For example, a solution after being used in the treatment of ore on testing shows no available cyanide. The cyanide in such solution is said to have been consumed, and is unfit for further treatment of ore until restrengthened by the addition of more cyanide. It is clear, therefore, that my process aims at, besides its other features mentioned, the substitution of a cheap amidine or amide compound (such, for example, as calcium cyanamide) in the place of cyanide or together with only a small proportion of cyanide.

"*Example 1.*—Two thousand pounds of pulverized ore is suspended in a solution of 4 lb. calcium cyanamide, 2 lb. caustic soda or lime (with or without the addition of 1 lb. potassium iodide) in 2000 lb. of water. The whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About 90 amp to 120 amp are used per ton of ore.

"*Example 2.*—Two thousand pounds of pulverized ore is suspended in a solution of 1 lb. of potassium cyanide, 2 lb. calcium cyanamide, 2 lb. caustic soda or lime (with or without the addition of 1 lb. potassium iodide) in 2000 lb. of water, the whole mixture being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About 90 amp to 120 amp are used per ton of ore.

"*Example 3.*—Two thousand pounds of pulverized ore is suspended in a solution of 2 lb. potassium ferrocyanide, 2 lb. calcium cyanamide, 2 lb. caustic soda or lime (with or without the addition of 1 lb. potassium iodide) in 2000 lb. of water. The whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through an electrolyzer having a current density of about 50 amp per square foot of electrode surface. About 90 amp to 120 amp are used per ton of ore.

"*Example 4.*—Two thousand pounds of pulverized ore is suspended in a solution of 2 lb. potassium thiocyanate, 2 lb. calcium cyanamide, 5 lb. pulverized calcium carbonate (with or without the addition of 1 lb. potassium iodide) in 2000 lb. of water. The whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About 90 amp to 120 amp are used per ton of ore.

"*Example 5.*—Two thousand pounds of pulverized ore is suspended in a solution of 1 lb. potassium cyanide, 2 lb. calcium cyanamide, 10 lb. pulverized calcium carbonate (with or without the addition of 1 lb. potassium iodide) in 2000 lb. of water. The whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About 90 amp to 120 amp are used per ton of ore.

"*Example 6.*—Two thousand pounds of pulverized ore is suspended in a solution of 1 lb. potassium cyanide, 1 lb. potassium thiocyanate, 1 lb. calcium cyanamide, 10 lb. calcium carbonate (with or without the addition of 1 lb. potassium bromide) in 2000 lb. of water. The whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About from 90 amp to 120 amp are used per ton of ore.

Regeneration of Cyanide.

"In this specification I have described my meaning of a non-available cyanogen-bearing solution, and I now give the following example as being a typical one for the regeneration of cyanide from spent cyanide solutions—that is, those solutions in which the cyanogen is non-available, such, for example, as cyanates, ferrocyanides, ferricyanides, sulphocyanides, etc.

"Example: Take 2000 lb. of solution which has an original strength of 2 lb. cyanide per ton and which has already been used for the treatment of ore, on testing shows only ¼ lb. of cyanide per ton of solution. Add 4 lb. of calcium cyanamide and electrolyze this mixture between inert electrodes for a period of two hours at a current density of 50 amp per square foot of electrode surface. On again testing the said solution it will be found that the available cyanide is increased, or rather gives a titration equal to 2 lb. of available cyanide. This solution is then ready for treating a fresh batch of ore. From the above it will be seen that ores which are readily leachable may be treated by percolation with the above-described electrolyzed solution.

"It will be seen that by my invention we generate solvents and continuously dissolve the precious metals which transform them into compounds soluble in the above solution. The function of the electric current in conjunction with a soluble amidine or amide compound (such, for example, as calcium cyanamide in the cyanogen-bearing solution) is one that is both reducing and oxidizing. It is clear that I make use of the anodic and cathodic reactions which occur at both electrodes in my solutions.

"From the above solutions or pulp the dissolved metals may easily be recovered by filtration and precipitation by methods well known and in use.

Effect of Additions. Treatment of Sulphides.

"It may be mentioned that the addition of a salt, such, for example, as sodium sulphate or ammonium sulphate, may be added to the solutions to render the same more conductive. In practice I find the addition of from 10 lb. to 20 lb. of either of the above salts to a ton of solution gives satisfactory results.

"In treating ores containing amongst other compounds sil-

ver sulphides or other sulphides it may not be necessary to add a halogen compound, such, for example, as potassium iodide, to the thiocyanate or cyanogen-bearing solutions, as the nascent oxygen produced by the electric current regenerates the alkaline cyanide from the alkaline thiocyanate.

"It is, therefore, obvious that after treating the silver ore or other sulphide-bearing ores with the ordinary cyanide solutions, the cyanide undergoes destruction and is said to be consumed (technically called cyanide consumption). Means at present employed to prevent this cyanide consumption and increase the extraction are the use of lead salts, such, for example, as lead acetate, litharge, etc., added to the cyanide solution, but these chemicals are expensive and irrecoverable and often inefficient when dealing with ores high in sulphides. The consumption of cyanide is largely due to the sulphide constituents of the compounds contained in the ores acting upon the cyanide solution in the presence of atmospheric oxygen; this gives rise to the formation of sulpho-cyanides—the formation of sulpho-cyanide represents a direct loss in cyanide because the cyanide is then in a non-available form and cannot be made to dissolve the precious metals by the ordinary means employed; but by my process a non-available cyanide solution is converted into an available cyanide solution, ready and active, together with any unconsumed cyanide, to dissolve the precious metals, which may be seen from reading the following descriptive example:

"Two thousand pounds of the pulverized sulphide ore are suspended in a solution of 6 lb. potassium cyanide (carrying 3 lb. to 5 lb. of protective alkalinity, the alkali used being preferably lime) in 2000 lb. of water; the whole mixture, being in the proportion of two parts of the said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously subjected to agitation and aeration by a current of air for a period of about 16 hours to 72 hours (the time depending upon the cyanide consumption). About when the cyanide consumption has ceased, the whole mixture of ore and solution is then subjected to electrolysis, in the said agitation tank, by introducing electrodes (preferably inert) into the said mixture carrying a current density of about 50 amp per square foot of electrode surface. About from 50 amp to 100 amp are used per ton of ore. The electrolysis is continued for about from 10 hours to 12 hours, the length of time depending upon the regeneration of the unavailable cyanide into alkaline cyanide. The latter may be determined hourly by titration or otherwise.

"From the above descriptive example it will be obvious that to start electrolysis of the ore pulp, together with the ordinary cyanide solutions, would result in immediate destruction of the cyanide, as there would be insufficient or no sulpho-cyanide present in solution to protect the cyanide against the nascent oxygen produced at the anode, which would at once oxidize the cyanide to cyanate.

Examples.

"I give the following examples of my process with and without the use of halogen salts without, however, limiting myself to the details of each.

"In the examples given the term electrolyzer has the same meaning as an agitation tank provided with electrodes, the circulation generally being caused by air agitation.

"*Example I.*—Two thousand pounds of pulverized ore are suspended in a solution of 2 lb. potassium thiocyanate, 2 lb. caustic soda or lime, 1 lb. potassium iodide in 2000 lb. of water; the whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a perid of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About from 90 amp to 120 amp are used per ton of ore.

"*Example II.*—Two thousand pounds of pulverized ore are suspended in a solution of 2 lb. potassium thiocyanate, 1 lb. potassium cyanide, 2 lb. caustic soda or lime, 1 lb. potassium iodide in 2000 lb. of water; the whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About from 90 amp to 120 amp are used per ton of ore.

"*Example III.*—Two thousand pounds of pulverized ore are suspended in a solution of 2 lb. potassium thiocyanate, 2 lb. caustic soda or lime, 2 lb. potassium bromide, ½ lb. potassium iodide in 2000 lb. of water; the whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About from 90 amp to 120 amp are used per ton of ore.

"*Example IV.*—Two thousand pounds of pulverized ore are suspended in a solution of 2 lb. potassium thiocyanate, 2 lb. of lime equal to 2 lb. of protective alkalinity in 2000 lb. of water; the whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously circulated for a period of 12 hours through the electrolyzer having a current density of about 50 amp per square foot of electrode surface. About from 90 amp to 120 amp are used per ton of ore.

Functions of Electric Current. Chemical Reactions.

"It will be seen that the function of the electric current is simply one to produce nascent oxygen in contact with the ore in said solution. The nascent oxygen in the above examples liberates iodine from potassium iodide which combines with the cyanide or the thiocyanate to form cyanogen iodide. This cyanogen iodide as produced is an excellent solvent for gold contained in refractory ores containing gold tellurides, sulphides, arsenides, etc.

"It may be seen from the following equations the reason for using thiocyanate alone or in conjunction with the simple cyanide solution in preference to the ordinary alkaline cyanide solution is that if cyanide solution be used without containing sulphocyanide or the addition thereof, the nascent oxygen produced by the electric current destroys the cyanide by converting the same into cyanate, which is not a gold solvent, and, therefore, simply results in the destruction of the cyanide—after the equation:

$$KCH + O = KCNO; \qquad (1)$$

whereas by using thiocyanate the equation is

$$KCNS + H_2O + 3O = KCN + H_2SO_4. \qquad (2)$$

It will be seen from the equation No. 2 that cyanide is produced when the solution is kept alkaline, and the cyanide so formed is not decomposed as long as there is thiocyanate present in the solution. By adding a halogen compound to the thiocyanate solution, which may or may not contain free alkaline cyanide and electrolyzing same, the following equation takes place:

$$KCNS + KI + 4O = ICN + K_2SO_4. \qquad (3)$$

"It may be stated at this point that any alkaline sulphides present in the solution would act to regenerate potassium thiocyanate as:

$$ICN + K_2S = KCNS + KI.$$

This reaction would also open up a way for substituting alkaline sulphides for zinc as a silver precipitant.

"The same solution can be used again and again by keeping the requisite strength in thiocyanate, but no further addition of potassium iodide is necessary, except to compensate for mechanical losses. The nascent oxygen produced by the electric current regenerates the iodine to begin work over again. Between each operation it is desirable to pass the liquor through

zinc shavings in the ordinary way to extract the values which it contains.

"In the above examples the desired result is prevented if the solution be substantially acid, but the solution may be alkaline, neutral or slightly acid. By slightly acid I mean this: That while a solution of thiocyanate may be technically termed 'slightly acid' because showing acidity to certain tests, yet for practical purposes it is substantially a non-acid solution, as well as those which are alkaline or neutral.

Use of Ozone.

"Another way of carrying my invention into practice is to treat pulverized ore with a solution of a thiocyanate containing a halogen compound with ozone or with a solution of thiocyanate containing a halogen compound in the presence of an electric current, as the following examples will make clear:

"*Example A.*—Two thousand pounds of pulverized ore are suspended in a solution of 4 lb. of potassium thiocyanate, 2 lb. of potassium iodide, 2 lb. caustic soda or lime in 2000 lb. of water; the whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously subjected to a current of ozonized air for a period of 12 hours, the amount of ozone passed into solution being about 100 grams per ton of ore. The amount of ozone present in the ozonized air is determined by titration or otherwise. The ozone liberates the iodine from the potassium iodide, which combines with the thiocyanate to form cyanogen iodide. This cyanogen iodide is an excellent solvent for gold contained in refractory ores containing gold tellurides, sulphides, arsenides, etc.

"*Example B.*—Two thousand pounds of sulphide ore are suspended in a solution of 4 lb. of potassium thiocyanate, 1 lb. of potassium iodide, 2 lb. of caustic soda or lime in 2000 lb. of water; the whole mixture, being in the proportion of two parts of said solution to one part of ore, is contained in an agitation tank. This mixture of ore and solution is continuously agitated for a period of 12 hours in the presence of inert electrodes having a current density of about 50 amp per square foot of electrode surface. About from 90 amp to 120 amp are used per ton of ore.

"The function of the electric current in example B is analogous to the function of ozone in example A—that is to say, both the electric current and ozone or ozonized air liberated the halogen from its compound."

New York Meeting of American Iron and Steel Institute.

The first formal meeting of the American Iron and Steel Institute was held in New York City on Oct. 14. It will be remembered that the Institute was founded to represent the commercial and economical rather than the technical side of the industry. Some 200 members were present when the president, Judge Gary, called the meeting to order at the Waldorf-Astoria. An international flavor was given to the meeting by the presence of some 30 prominent representatives of the steel industries of Great Britain, Germany, Austria, France and Belgium. Practically every American steel company and many blast furnace and rolling mill companies of this country were represented.

The proceedings started with the presentation by Judge Gary of his presidential address on the maintenance of steady conditions and co-operation in the steel industry. The address, dealing with fundamental problems of social economy, was exceedingly interesting. It will be found on page 613 of this issue.

The following papers were then presented

Mr. James A. Farrell, president of the U. S. Steel Products Export Company, spoke on "Foreign Relations."

Mr. Wm. B. Dickson, first vice-president of the U. S. Steel Corporation spoke on "The Betterment of Labor Conditions in the Steel Industry," dealing with prevention of accidents and employers' liability and hours of labor.

Mr. Charles Kirchhoff gave a concise summary of the proceedings of the International Metallurgical Congress, held this summer in Düsseldorf.

Mr. Willis L. King, vice-president of the Jones & Laughlin Steel Company, spoke on "Contract Obligations," dealing with the dividing line between contract and option.

In the evening a dinner attended by over 200 members and guests was held in the ballroom of the Waldorf-Astoria. A very interesting series of lantern slides, showing the town of Gary in the making, was exhibited and commented upon by Mr. George G. Thorp, vice-president of the Indiana Steel Company.

Judge Gary in opening the after-dinner speeches emphasized the idea that the assembled iron and steel manufacturers advocated the gospel of peace and good will and co-operation instead of destructive rivalry. Mr. Charles M. Schwab welcomed the guests from abroad. Sir John Randles replied for England, Baron von Bodenhausen for Germany, Mr. L. Spark for Belgium and Mr. R. de Labriolle for France. Mr. G. S. Smith, Mr. E. Schaltenbrand and Mr. Wm. B. Peat also spoke.

Baron von Bodenhausen, of the Krupp Works in Essen, Germany, put in a good word for competition. But one should know his competitor and be friendly with him. While to know one's customers personally means half of business success, the other half of success is to know his competitors personally.

Mr. Wm. B. Peat, who was the last speaker, thought the day to be past when a policy of cut-throat competition was considered the best either for a country or for individuals. Good feeling between those engaged in competitive commerce is able to smooth over difficulties which would otherwise prove insurmountable.

On Saturday, Oct. 15, an excursion was made by the members and guests of the Institute on a steamer around New York City.

On Sunday, Oct. 16, a tour by special train started covering Buffalo (Lackawanna Steel Company), Niagara Falls, Chicago (Indiana Steel Company at Gary, Illinois Steel Company at South Chicago, International Harvester Company, Union Stock Yards), Pittsburgh (Jones & Laughlin Steel Company, Homestead works of Carnegie Steel Company, works of Mesta Machine Company, Carnegie Technical Schools, Westinghouse Works), and Washington (Bureau of Standards). Social features of the trip were dinners at Chicago and Pittsburgh, and the reception by President Taft at Washington. Judge Gary addressed the President briefly, who in his reply referred to the basic character of the iron and steel industry. The members of the party were then presented to President Taft.

The trip ended on Saturday night, Oct. 22, by the return of the special train to Jersey City.

The Camp Bird, Ltd., Ouray, Colo., treated 6813 tons of ore during August, 1910, producing 6280 oz. of bullion and about 800 tons of concentrates. The financial statement shows about $150,315 applicable to profit. In the annual statement for the year ending April 30, 1910, it is stated that during the year a saving of 95 per cent was made on the gold value of the ore, which is the record saving in the history of the company's operations. Of the total value recovered there was obtained through amalgamation 70.85 per cent; through concentration, 21.71 per cent, and through cyaniding, 7.44 per cent. Of the metals recovered, gold constitutes 95.50 per cent; silver, 2.84 per cent; lead, 1.52 per cent, and copper, 0.14 per cent. At the company's Santa Gertrudis property, Mexico, a mill of 600 tons daily capacity is under construction and should be in operation by March 1, 1911. It will have modern coarse crushing equipment, followed by 60 1550-lb. stamps and 10 tube mills. The plant will include Pachuca tanks and the latest developments in filter and precipitation practice.

Chicago Meeting of the American Electrochemical Society

The great success of the Pittsburgh meeting in the spring of this year encouraged the officers of the American Electrochemical Society to go still further westward and to accept the invitation of the newly formed Chicago local section to hold its fall meeting in Chicago.

The success of the Chicago meeting has proved that this was a wise policy. It will strengthen the influence of the society in the West, where there is open for it a wide and important field of usefulness.

The local Chicago committee had arranged all details with greatest carefulness and foresight and all Chicago members did their best to make the visitors feel at home and succeeded admirably. Special mention should be made of the indefatigable work of the chairman of the local committee, Dr. H. N. McCoy, and the secretary, Mr. Arva B. Marvin, as well as the chairmen of the various sub-committees, Mr. Harry McCormack, Entertainment Committee; Mr. F. T. Snyder, Excursion and Transportation Committee; Mr. H. T. Matthew, Press Committee, and Mrs. W. D. Richardson, Ladies' Committee.

W. H. WALKER, PRESIDENT, AMERICAN ELECTROCHEMICAL SOCIETY.

The attendance at all sessions was very gratifying. The last printed registry list contained 213 names, of which 100 were from other cities than Chicago.

Of particular interest were the visits and excursions which had been arranged for the three afternoons. There were, indeed, so many of them that it was often hard to select the one most desirable out of three or four alternate excursions for one afternoon.

Of greatest metallurgical interest were the visits to the magnificent Gary steel works of the Indiana Steel Company and to the equally famous South Chicago works of the Illinois Steel Company. At the latter place the 15-ton Héroult electric steel furnace (see description in our April issue, p. 179) was seen in operation.

Of great general interest was the visit to the Union Stock Yards and packing plants, where the most interesting sections of the plants of Swift & Co., Armour & Co. and Morris & Co. and the Libby canning establishment were visited. At the Morris plant the chemical laboratory and the butterine factory were shown. Chemistry plays a greater part in the packing plants than is generally appreciated. Thus in the laboratory of Swift & Co., which is in charge of Dr. W. D. Richardson, some thirty chemists are employed and it is interesting to learn that about half of the work is analytical routine work in connection with the soap, etc., manufacture, while the other half is research work to find new uses for the by-products.

Of equally great general interest was the visit to the mail-order establishment of Sears, Roebuck & Co., with a unique organization which in its way is not equaled elsewhere.

There was also quite a number of excursions to plants of electrical interest. Among them were the Fisk Street power house (a 120,000-kw steam plant with 12,000-kw generating units driven by Curtis steam turbines) and the Market Street converter and storage battery station of the Commonwealth Edison Company; further the telephone and instrument factory of the Western Electric Company, the factory of the Automatic Electric Company, where 1300 persons are employed in the manufacture of automatic telephones.

The Hoskins Manufacturing Company (represented by Mr. W. V. Young and Mr. A. L. Marsh) had at its salesroom an interesting exhibit of various electric furnaces for laboratory work, and especially for steel works laboratories, in connection with pyrometers. An instructive pyrometer exhibit, comprising quite a number of different types, had been arranged at the Congress Hotel by the Taylor Instrument Companies of Rochester, N. Y. (represented by Mr. R. S. Schwarz and Mr. J. A. Sutherland), while the firm of E. Leitz, of New York and Chicago (represented by Mr. H. Vollrath), exhibited its new metallographic microscope.

For Saturday afternoon visits to the laboratories and museums of the University of Chicago and to the Field Columbian Museum had been arranged, while another party visited the Lockport power station and drainage canal. The canal is one of the world's great artificial waterways. It receives the drainage of the city diluted by a large volume of pure water from the lake. At Lockport, 35 miles from the lake, the canal empties into the Des Plaines River with a 36-ft. fall. The Sanitary District has at this place a modern generating plant of 36,000 hp.

On the evening of Friday a delightful informal subscription dinner was held at the Congress Hotel, Mr. H. B. Coho acting as toastmaster. Among the speakers were Mr. Harry McCormack, chairman of the Sanitary District, who gave some interesting details of the building of the drainage canal and its connection with politics, and Mr. E. A. Sperry, chairman of the New York section, who invited the society to hold its next meeting in Spring, 1911, in New York City.

The two professional sessions of Thursday and Friday morning were held in the Congress Hotel, that of Saturday morning in the lecture room of the Kent Chemical Laboratory of the University of Chicago.

President Dr. Wm. H. Walker called the first meeting to order on Thursday at 10 o'clock. The first two papers dealt with the general subject of heat insulation of electric furnaces.

Determining Thermal Conductivity.

A paper by Mr. CARL HERING, of Philadelphia, Pa., suggests a new method of determining the thermal conductivity of refractory materials, such as used for furnace walls. In determining the heat flow through a specimen the lateral leakage of heat is troublesome. Mr. Hering shapes his test piece so that it has no lateral sides at all.

The ideal case is to shape the sample piece in form of a hollow sphere. The inside is filled with a good heat-conducting material, like a molten metal, which is heated electrically, say, by means of an insulated coil of wire. The outside is surrounded by any suitable liquid, preferably kept in good circulation as it receives the flow of heat; this liquid is provided with a cooling worm which carries off the heat exactly as fast as it arrives through the sphere. The temperatures of the inside and outside surfaces of the sphere are determined by means of pyrometers or thermometers and the electric energy set free in the inside is measured by means of an ammeter and a voltmeter.

These measurements are made when the stable state has been reached. The thermal conductivity k (in watts for 1 in. cube for one degree C.).

$$k = \frac{l}{\sqrt{S\,s}} \frac{W}{T}$$

Where W is the energy in watts set free in the inside, T the difference between the inside and outside temperatures in degrees C., l the thickness of the shell in inches and S and s the outside and inside surfaces in square inches.

The conductivity may vary with the temperature so that it would be different in different parts of the sample. But the above method gives directly the "true and correct average or effective mean" of the conductivity for that range of temperature, that is, it is that conductivity which an equivalent piece of material would have whose conductivity is constant over that range of temperature, and which as a whole acts just like the sample.

While the hollow sphere is the ideally perfect form to use in this test, because it is absolutely symmetrical all over, it is probably also the most impractical. Mr. Hering suggests as a convenient form of the test samples a cylindrical cup, rounded at one end and open at the other, as shown by C in the adjoining Fig. 1, which is a diagrammatic vertical cross-section of the whole apparatus. The inside is nearly filled with the heating liquid containing the heating coil; the outside vessel is nearly filled with the cooling liquid and its cooling worm. T and t are the two temperature measuring instruments. When both temperatures are very high the outside liquid may also be a molten metal, in which case it had better also be provided with a heating coil to save the time it would take to heat it with the heat which has to pass through the test piece; but the heat generated in this coil, of course, need not be measured.

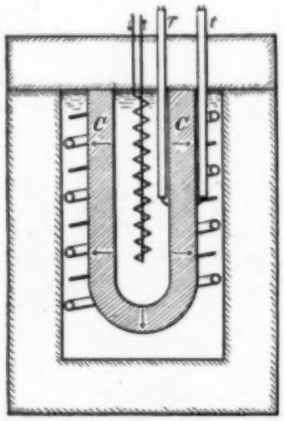

FIG. 1.—APPARATUS FOR MEASURING CONDUCTIVITY.

The objection to this form is that there will necessarily be some loss of heat through the cover over the top. This can be made relatively small, however, and can also be allowed for. Care should, of course, be taken to mold or grind the test cup so that its wall thickness is the same throughout. For testing loose, granular or fibrous materials, like infusorial earth, sand, asbestos, magnesia, etc., the cup may be made of two thin shells of iron, the material to be tested being filled in the space between them.

For such a cylindrical cup, with its one end rounded off to a half sphere, the value of the thermal conductivity k is as follows:

$$k = a\frac{W}{T}$$

in which a is a constant, calculated once for all for each test piece, and is equal to

$$a = \frac{l \log D/d}{2.7288\, l\, L + 1.5708\, D\, d \log D/d}$$

k is in watts for 1 cu. in. or 1 cu. cm., depending upon the linear units used for the other quantities; W represents the watts generated in the inside of the cup when the stable state has been reached (after deducting the loss through the lid); L is the length of the straight part of the cup, down to the beginning of the hemispherical bottom; l is the wall thickness of the cup; D and d are the outside and inside diameters, respectively; T is the drop of temperature in centigrade degrees between the inside and outside surfaces of the cup; all linear dimensions must be either in inches or in centimeters, and the value of k will then refer to inches or centimeters respectively; *log* in the above formula means common logarithm. The constants in this formula are purely mathematical and involve nothing empirical.

In the discussion Dr. Richards referred to experiments made by Prof. Landis with a hollow sphere, electrical energy being generated at the center and thermocouples being inserted at different points of a radius to determine the gradual temperature drop from the inside to the outside. When a graphite sphere was used it was impossible to keep the outside temperature of the sphere cool as desired on account of the good conductivity.

Mr. F. T. Snyder referred to the method of Clement and Egy, which was described and illustrated in our July issue, page 414. They use a test piece in form of a cylinder and this has the advantage that manufacturers of refractory material have no difficulty in getting the test piece into this form.

Flow of Heat Through Furnace Walls.

Mr. F. T. Snyder, of the Metallurgical Engineering Company of Chicago, presented a paper on the flow of heat through furnace walls. He analyzed the part which heat convection and heat radiation play in compound furnace walls, consisting of several layers of different materials.

Mr. Snyder uses as the unit of heat flow the temperature drop in degrees Centigrade per inch of thickness per kilowatt per square foot. The constituent units are the actual ones in which the data comes to the designer. The furnace drawings give dimensions in feet and inches; American refractories are made in inch dimensions and the pyrometers usually available are calibrated in Centigrade degrees.

The radiation of heat from the outside surface varies with the difference between the fourth powers of the absolute temperatures of the surface and the air, multiplied by a constant to deduce the results to kilowatts of heat flow per square foot. The convection of heat from the surface is affected by two factors, the transfer resistance of the flow of heat from the surface to the air, and the movement of the heated air away from the surface.

The radiation according to Stephan's law is

$$R = a\,(T^4 - t^4)$$

where

R = kilowatts per square foot.
T = hot temperature.
t = cold temperature.
a = 0.0033×10^{-9} for ordinary sheet iron.
a = 0.0042×10^{-9} for brick and slag.

The convection of heat from the surface to the air as function of the velocity v of the convection currents is given by the formula

$$C = b\,(T - t)\,(2 + 5.5\,\sqrt{v})$$

where

C = kilowatts per square foot.
T = temperature of furnace surface.
t = temperature of air.
b = 0.00011 for sheet iron furnace shell.
b = 0.00015 for black furnace surface.
v = velocity of convection currents in feet per second.

The velocity of the convection currents is in turn determined by the temperature of the surface. Strictly this velocity is also affected by the shape and position of the surface, but practically it has been found from measuring the velocity of the air for different points on the bottom, sides, and top of a number of commercial electric furnaces and plotting it against the temperatures of the surface for the same points that this velocity can be expressed as a simple function of the difference between the temperatures of the surface and the air. This empirical formula is

$$v = 0.0022\,(T - t)^{3/4}$$

For the flow of heat through the wall material an experimental constant is determined giving the temperature drop in degrees C. through one inch of thickness of the material for a heat flow of 1 kw per square foot. This constant varies for any material with the temperature range and should be used only for the range for which it is determined. If not available for a desired range, it may be approximated from the

constant of a known range by varying the known constant inversely as the absolute temperatures of the means of the two ranges.

A set of data for different materials is given in the following table:

Thermal Conductivity of Refractories.

D = Degrees C. required to force a heat flow of 1 kw per square foot through 1 in. of thickness of the material.
T = Temperature at hot side of material.
t = Temperature at cold side of material.

	t	T	D
Alumina brick	0	700	320
Ashes, wood	0	100	3840
Brick dust, coarse	0	100	1680
Carbon, retort, solid	0	100	45
" electrode	100	400	7.1
" "	100	800	5.2
" "	100	1200	5.0
" "	100	1600	4.5
Carborundum sand	18	98	1300
Cement	0	700	3800
Charcoal	0	100	2960
Clinker, small grains	0	700	600
Coke, powdered	0	100	1480
Copper metallic	0	30	0.7
Fire brick	0	500	465
" "	0	1000	155
" "	0	1300	105
" " dust	20	98	2300
Graphite, dust	20	100	1630
" electrode	100	400	1.9
" "	100	800	2.1
" "	100	1200	2.3
" "	100	1600	2.5
Infusorial earth	17	98	5000
"	0	650	1720
Iron, metallic	100	200	4.4
Lime	20	98	2250
Magnesia, brick dust	20	100	1300
" calcined, Grecian, granular	20	100	1450
" " Syrian "	20	100	1920
" " light, porous	20	100	4100
Quartz sand	18	98	1090
Silica brick, burned to 1050 C	0	1000	330
" " " " 1310 C	0	1000	210

Mr. Snyder shows in detail how to calculate the heat flow and temperature distribution for a proposed furnace wall and gives various curves for practical use. Finally a numerical example is added on the calculation of the temperature distributions through the bottom of a small steel furnace.

In conclusion, Mr. Snyder remarks that with regard to the published data of the actual heat flow through composite walls, allowance should be made for the fact that the water jacket usually used to absorb the heat for measurement on the outside changes the regular operating conditions, firstly by cutting off the convection and secondly by cooling the outside of the wall below its usual working temperature.

In the discussion which followed Mr. Hering referred to the fact that there is no temperature equilibrium between a moving gas or liquid and a surface in contact with it. There is at the contact a sudden temperature drop. This is, for instance, so in boilers.

Dr. Richards referred to a simple method of testing a given furnace of given wall thickness and given dimensions. The temperature of the outside of the furnace may be explored by means of an iron-nickel wire thermocouple. The outside temperature determines the loss. The radiation losses can be reduced by experimenting with the form of the outside shell of the furnace, since the radiation depends on the roughness, porosity, color, etc., of the surface. The harder the outside shell the more economical is the furnace.

Reduction of Tin Dross.

Mr. R. S. WILE, of the Riverside Metal Refining Co., of Connellsville, Pa., discussed the reduction of tin dross in an electric furnace.

Electrical heat was resorted to for the smelting of tin dross because of the fact that the heat could be internally applied to the slag, which is on the bottom of a shaft-type of furnace, thus enabling the dross to be thrown on top of the slag instead of being mixed with it as is done in the old style of furnace. The dross, being on top, comes in contact with the slag only at the point of reduction. The liberated gases filter through the dross, while any tin oxide which is volatilized is condensed in the colder portion of the dross, which is on top of the slag. The globules of tin produced in smelting pass downward through the slag and lose most of the impurities, so very little refining of the resultant product is necessary.

In operation, the top carbon, which is movable, is brought into contact with the lower carbon, which is stationary, and an arc formed. The slag is fed in and melted, and the carbon is raised until the desired amount of slag is added. The dross, mixed with the right percentage of carbon, is added, and the tin tapped from the bottom from time to time. The loss of tin has been kept as low as 0.25 per cent, and the average below 1 per cent. The amount of tin recovered varies largely on account of the varying percentages in the drosses treated. The average is about 2500 lb. (1100 kg) per day.

The plant consists of two furnaces, connected in series, both being 20 in. (50 cm) in diameter and 80 in. (200 cm) high inside, two 50-kw transformers and necessary electrical apparatus. In operation they consume about 44 kw. During the run it is desired to keep the amperage as near constant as possible, the voltage varying. At the start the voltage of each furnace is about 80, but toward the end, as the slag becomes less refractory, due to the combination of the iron and zinc of the dross and the slag, the voltage of each furnace will drop as low as 45 or 50. This and an analysis of the slag denotes the end of the operation, and the slag must be drawn out and new put in. This is done alternately with each furnace. The furnaces run continuously until time to be relined, which is about every three or four months.

In the discussion Dr. J. W. Richards remarked that this electric furnace process represented a rather general method which could prove useful for other purposes than the reduction of tin dross.

Cast Copper of High Electric Conductivity.

A paper by Dr. E. WEINTRAUB, of the West Lynn, Mass., research laboratory of the General Electric Company, was then presented on a new method of producing copper castings of high electric conductivity.

The production in the foundry of pure copper castings mechanically sound and possessing an electrical conductivity comparable to that of pure forged copper has been an important problem ever since the development of electrical machinery and apparatus. The literature as well as the patent files are replete with descriptions of methods for accomplishment of this result. Secret compositions, warranted to give high conductivity copper, were and are being sold to foundrymen, and there are but few foundry foremen to be met with who do not claim to have some time or other obtained the desired result by adding "phosphorus" or similar material. Obstinately, however, the casting of high-conductivity copper refused to make its entrance in the foundries and it may be assumed that there were good reasons for it.

The cause of the difficulty of producing sound pure-copper castings has been sufficiently well understood for a long time. Molten copper has the property of dissolving gases such as oxygen and of setting a part of these gases free on cooling. This produces pin holes and even big cavities. The casting obtained is, therefore, mechanically unsound and has naturally a low electrical conductivity.

The elimination of these dissolved gases presents but little difficulty. It is sufficient to add one of the well-known deoxidizers such as zinc, magnesium, phosphorus, etc., in small quantities to bind the oxygen chemically. Copper castings free from blow holes are thus easily produced. The electrical conductivity of the copper thus produced is, however, as a rule, low; and this because all the deoxidizers used had also the property of combining with copper, and the remarkable rate in which the conductivity of copper drops when small amounts of impurities are alloyed with it is well known. The amount of oxygen dissolved in copper during the process of melting is a variable quantity and is distributed throughout the whole mass. It is, therefore, practically impossible to add the deoxidizer in such a way as to eliminate oxygen completely without, at the

same time, alloying it to a certain degree with the copper. Accordingly, the conductivity of the resultant product was a matter of accident. In the laboratory sometimes good results were obtained, but they were hard to duplicate and the transfer to the foundry was always a disastrous experiment.

Dr. Weintraub argued that what was needed for the solution of the problem was the finding of a deoxidizer which would have no affinity for copper (at least at the melting point of the latter) and which, therefore, could be added in excess with impunity.

While carrying on the work of the isolation of the pure element boron (this journal, vol. VII, page 509) and its fusion, the lack of affinity of this element for copper manifested itself. Boron has, at the melting point of copper, a great affinity for oxygen, nitrogen, etc., and it occurred to Dr. Weintraub, therefore, that boron ought to be the ideal substance for deoxidizing copper.

Pure boron, as prepared by methods described in his former paper, can by this time be produced in large quantities and is rather inexpensive for uses based on its electrical properties. For casting copper, however, its price would probably be too high.

In the course of the investigation mentioned he had prepared, however, an amorphous powder which contained as essential impurity only a certain percentage of oxygen and which he termed "boron suboxide." The substance is prepared by a modification of the reduction-process of boric anhydride by magnesium. Obviously for the purpose of eliminating oxygen from copper without introducing any impurity capable of alloying with copper this boron suboxide would be as good as pure boron or perhaps better on account of its being obtained in form of a very fine powder.

This substance was used in the first experiment. The very first attempt was successful. A perfectly sound bar was obtained with a conductivity of 94 per cent; 0.1 per cent of the weight of the copper was added. Further experiments showed that the amount of boron suboxide could be reduced to 1/30 per cent and also that the addition of a large excess, say of 1 per cent, did not diminish the conductivity or change in any way the mechanical properties of the cast copper.

Here was, therefore, a method which could be put into the hands of any foundryman and which would always give good results provided the copper (ingots or scrap) melted down was pure metal.

A further simplification could, however, be introduced into the process. The reduction of boric anhydride of magnesium, the first being in excess, gives a product containing magnesium borate, boric anhydride and boron suboxide. While the last one is the active agent, the first two are harmless. In fact the presence of boric anhydride and magnesium borate is even an advantage, as the addition of a larger mass of material makes the operation easier; also the boric anhydride would probably dissolve the copper oxide and bring it to the surface as copper borate. It is therefore unnecessary to submit the direct product of the reaction to chemical treatment for the purpose of isolating the boron suboxide. It is sufficient to grind up the mixture into coarse grains and use an amount of it which contains the necessary amount of boron suboxide.

The foundry practice at present is to add 1 per cent to 1½ per cent of this material, which is equivalent to 0.08 per cent to 0.1 per cent of boron suboxide. The properties of the material obtained are as follows:

The electrical conductivity obtained can be as high as 97½ per cent if the copper melted down is perfectly pure. In the foundry, where the scrap copper which is melted down cannot always be very carefully selected, a conductivity of 91 to 95 per cent is obtained and a guarantee of 90 per cent is given.

The resultant casting is readily machined; fears which were entertained on this subject did not materialize and the engineers using the material have not complained on this account. The mechanical properties are as follows:

Tensile Strength.	Elastic Limit.	Elongation.	Reduction in area
24,350	11,450	48.5 per cent.	74.49 per cent.

Castings are being made of all shapes and sizes with no more difficulty than in the case of brass. Sand and iron molds can be used and for standard articles the latter are preferred.

The use of cast copper lies in two different directions: (1.) Replacing forged copper. In this case a great saving in cost is often obtained. (2.) Replacing alloys of copper. The gain in conductivity allows a reduction in bulk and thus a saving in material.

The use of this material is spreading as the engineers get better acquainted with it and is already of considerable magnitude. It is interesting to note that in spite of the fact that cast copper has lower conductivity than forged copper in many cases, as for instance, in case of current transformers, cast copper is being used now instead of forged copper. This is due to the fact that in casting a chance is given to eliminate riveted, screwed or soldered joints, whereby a number of poor contacts are avoided. Not only this, but the elimination of joints often insures a better operation.

The cost of the boron added is small; at the present prices of magnesium and boric anhydride the cost per pound of copper is less than ¾ cent.

The success with "boronizing" copper, as it is now called in the foundry, suggests new lines of work which have been taken up lately by Dr. Weintraub. Among these are mentioned:

First, the addition of boron to different copper alloys.

Second, the replacing of the poling operation in the process of refining copper by a "boronizing" operation.

In conclusion Dr. Weintraub acknowledged the assistance of Mr. F. A. Kroner.

Induction Furnace for Steel Melting.

Dr. Jos. W. Richards, of Lehigh University, presented a paper on the Hiorth induction furnace, which is in commercial operation for steel melting in Norway. He first made some general remarks on the status of electrometallurgy in Norway and Sweden.

At the Hiorth plant, which is located on a fjord in Norway, there are available 1000 hp electric power, of which 500 hp are used in the Hiorth furnace plant and the balance for a pulp mill. The entire cost of installation was $25 per horse-power and the total cost of the electrical energy, including interest and depreciation, is stated to be between $3.80 and $4.10 per electric horse-power-year. This is, according to American ideas, an exceedingly low price, but Mr. Eyde has added that equally cheap power is available elsewhere in Norway. In addition, these water-powers are located right next to the ocean and there is direct deep-water communication with the markets of Europe. The only drawback of Norway is the labor problem, due to the lack of population.

It is different in Sweden. There the water-powers are somewhat more expensive, the cost of the horse-power-year being between $7 and $10. But the labor supply is better. Further, Sweden has had for many years considerable experience in iron and steel making.

The Hiorth furnace is a double induction furnace, the two rings being in communication with each other at the center, where a wide hearth is provided for carrying out the operations quite similar to the Roechling-Rodenhauser arrangement. The arrangement of the furnace and of the primary coils (which are in two parts, one above and one below the bath) is such that the magnetic leakage is claimed to be small.

The frequency of the alternating current employed is 12.5 cycles and the power factor is stated to vary between 0.75 and 0.85.

Means are provided for supplementary heating in the central compartment, quite similar to the Roechling-Rodenhauser furnace, to keep its temperature up. But in actual practice it has been found that this supplementary heating was not absolutely necessary; even when the furnace was run as a pure induction

furnace, the temperature of the central compartment was quite as high as that of the outside rings. While the current density was low in the central compartment, yet the radiation loss was small.

The metallurgical process carried out is exceedingly simple. What they are doing at the Hiorth works is to take the same high-grade materials which are melted in Sheffield in crucibles and melt them in the Hiorth electric furnace. These are Dannemora pig iron, costing about $25 a ton, and Dannemora soft iron, costing $50 a ton. The ingots are shipped to Sheffield. At the Hiorth plant nothing is being done but melting down the starting materials to ingots. The plant is commercially successful.

The lining of the hearth of the Hiorth furnace is magnesite. They use Syrian magnesite, since their experiments with Norwegian magnesite were not successful. Dr. Richards thinks that the reason was probably that it had not been calcined at a sufficiently high temperature. For full success it is important that the magnesite be very hard burned.

The slag from Dannemora blast furnaces has been used successfully in the electric steel furnace.

As to the specific energy consumption, Dr. Richards stated that at the time of his visit to the Hiorth plant 700 kw-hours were required per ton of cold material charged into the furnace. But since that time he has been informed that this figure has been reduced to 685 to 690 kw-hours.

The steel produced in this way has proved in every respect equavalent to the best Sheffield crucible steel.

While the Hiorth furnace is thus used simply for melting down high-grade starting materials, Dr. Richards pointed out that another application would be the dead-melting of ordinary open-hearth or Bessemer steel; the power consumption would be low and the steel would be improved over ordinary open-hearth and Bessemer steel, as is known to be the case.

Since the large central space is available, a certain amount of refining could also be done, but the two special fields of the Hiorth induction furnace are the melting down of high-grade material and the dead-melting of ordinary steel.

The paper was discussed by Messrs. Seede, Hering, Bennie and Frary.

Triboluminescence.

The first paper presented at the Friday session dealt with triboluminescence, the author being Mr. W. S. ANDREWS, of the General Electric Company. Triboluminescence is the property possessed by certain bodies of emitting light when rubbed or scratched. An artificial product showing triboluminescence can be easily prepared from 70 parts by weight of chemically pure zinc carbonate, 30 parts of flour sulphur and a trace of manganese sulphate.

The zinc carbonate in fine powder should first be mixed with the flour sulphur. Then a small particle of manganese sulphate should be dissolved in distilled water and enough of the solution added to the powdered materials to make a thick cream. After being thoroughly triturated in a mortar, the mixture can be poured into a shallow glass or earthenware dish and allowed to dry at a gentle heat. When quite dry it should be again reduced to a fine powder and packed hard into a porcelain or Battersea crucible with a tight cover and subjected to a bright red heat for twenty minutes. The mixture shrinks considerably and sinters together into a stone-like mass, which possesses the peculiar property of triboluminescence to a marked degree, so that when scratched with a knife blade or sharp point it emits a train of minute sparks showing a yellowish light. This light appears to have little or no heating effect as it will not ignite any inflammable vapor or gas, so that in this regard it differs essentially from the light and sparks produced by striking together flint and steel or the scratching of a pyrophoric alloy of iron and cerium.

A sample of this material exhibiting triboluminescence was shown and it was suggested in the discussion that the phenomenon might be due to the formation of zinc sulphide.

Electrolytic Preparation of Calcium.

Prof. ARDEN R. JOHNSON presented a paper on the electrolytic preparation of calcium, giving the results of experimental work carried out in 1905-6, but not published before.

Two different designs of apparatus are distinguished; first, that of Borchers, using a very high current density and consequently obtaining the calcium in molten condition, in which it rises to the surface and is skimmed off; and, second, that of Rathenau, in which the calcium is plated out at a moderately low current density and is obtained in form of a solid stick which is gradually raised out of the electrolyte.

The author first tried an apparatus of the Rathenau type and described the difficulties which he encountered with it and with a modified form of apparatus. These were especially the formation of nodules and trees and the contamination of the metallic calcium deposit with undecomposed calcium chloride. In the last experiments an iron ribbon was used as the cathode on which the calcium was deposited and which was gradually raised, presenting new cathode surface.

A considerable amount of data are given in the paper on current efficiency, chemical changes in the electrolyte, and decomposition voltages.

In the discussion Prof. Frary said that no troubles are experienced in the production of metallic calcium on a commercial scale at Bitterfeld by the Rathenau process and that Prof. Johnson's troubles were chiefly due to not using an artificially cooled cathode. Prof. Johnson thought that his ribbon cathode was a kind of cooled cathode. According to Prof. Frary, current density is important only as it determines cathode temperature. The cathode temperature is the main thing. When the metallic calcium is set free in molten state, it should be frozen as soon as possible. At Bitterfeld rods of calcium are produced 1 and 1½ in. in diameter, perfectly solid and containing no chloride.

Efficiency in Production of Metallic Calcium.

Prof. FRANCIS C. FRARY, of the University of Minnesota, presented a paper on the ampere-hour efficiency in the electrolytic production of metallic calcium. Messrs. H. R. BICKNELL and C. A. TRONSON being joint authors with him.

The main thing, in order to obtain a good efficiency, is to withdraw the cooled calcium stick cathode at the proper rate. The addition of electrolyte is also of importance, and both the raising of the cathode and the addition of electrolytic should be continuous. The aim of the authors was to withdraw the cathode as rapidly as was possible without striking an arc. Practice in doing this increased the yield obtained. In none of the ten runs made the ampere-hour efficiency was less than 45 per cent and in three runs it was raised to practically 100 per cent.

When the electrolysis is going on properly, and the stick of metal is at the right depth, the electrolyte seems to flow rather rapidly across the surface in a fixed direction and is hottest at the cathode. The operator must be guided by the appearance of the electrolyte at the cathode. There should be a rosette-like spot with radial markings here; if the stick of metal is pulled out too fast this spot becomes almost white hot, and if the metal is not at once lowered an arc forms, and part of the metal is melted off and lost. If the stick is not raised fast enough the spot becomes less noticeable and spongy metal deposits below the surface, causing losses. When the electrolysis was well under way new electrolyte was added in small portions, taking care to make these additions as continuous as possible, and in such a spot that the convection currents carried the cold chloride away from the metal.

The authors tried both plain chloride and a mixture of chloride and fluoride as electrolyte, but from their experiments they conclude that the plain chloride is a little more satisfactory than the mixture of the chloride and fluoride in point of efficiency and decidedly easier to manipulate. Satisfactorily high efficiencies can be obtained with it, and efficiency is more

largely a matter of careful regulation of conditions than anything else.

In reply to a question of Mr. Hering as to the watt-hour efficiency Professor Frary explained that the voltage applied varied between 18 and 42, which is many times the theoretical voltage (3.2 volts), so that the watt-hour efficiency may be less than 10 per cent. But the excess energy is not wasted, as it is employed for heating.

Polonium.

Prof. A. R. Johnson presented a preliminary paper on the electrochemistry of polonium and other radioactive elements. He prepared the material from pitchblende by the methods used by Boltwood and others. He tried to separate the polonium by plating it out electrolytically. Polonium is a metal less electropositive than copper and bismuth. It is precipitated by copper, but not by mercury. In electrolysis polonium moves in the electrolyte with the current like metals.

The quantity of polonium plated out of the solution was so small that it could not be weighed, but only detected by its radioactivity. The author made some speculations as to the applicability of Faraday's law. If polonium behaves in electrolysis like other metals, why does it require such an enormous amount of coulombs to deposit an infinitesimal amount of polonium? He suggested the possibility of an abnormally high valency or an abnormal electrochemical equivalent.

In the discussion Dr. Schlundt referred to similar experiments of his own. To make the deposition complete it takes several days. Dr. Kahlenberg pointed out that in order to apply Faraday's law one must make sure that nothing but polonium is deposited, or it must be known how much of other substances is simultaneously deposited. Dr. Richards and Mr. Hering pointed out that as polonium was present in an almost infinitely dilute solution, it was not surprising that it took so many coulombs to get it out.

Ozone.

Mr. Ralph D. Small, of the Standard Electro-Utilities Company, of Chicago, presented a paper on the present status of ozone, with special reference to air purification.

There are various ways of producing ozone, such as the oxidation of phosphorus or the action of ultra-violet rays upon air, these rays being produced by a mercury-vapor lamp in a quartz receptacle, or by heat, according to Nernst and Clement, by which they produce 3 grams per kw-hour. But commercially ozone is now chiefly produced by electric discharges through air.

Alternating current is required. Direct current must first be converted into alternating current, peferably with a frequency of not less than 60 cycles. The voltage is then raised in transformers up to any voltage between 5000 and 30,000, although it is now thought that to obtain the highest economy a voltage below 8000 is poor practice. The discharge is produced between electrodes on either side of a dielectric, such as glass, micanite, mica or some high-insulating material, there being an air-gap between the dielectric and the electrodes. The electric discharge, which is not accompanied by sparks and which is comparatively heatless, is a brush discharge, purple in color and fairly quiet in its action.

The consensus of modern opinion is that point electrodes, such as employed by Andreoli and others, have various disadvantages, firstly, because they quickly lose their pointed character and round off; secondly, because a minute particle of dust can do a great amount of destructive work on a small point in generating heat and interrupting the flow of electricity; thirdly, because the necessary cleaning of an indefinitely large number of points requires too much attention.

Other types of electrodes are either plates or cylinders on either side of a dielectric material, and these may be made in various forms, flat, serrated, graded or perforated. Another type is the covered electrode with no metal exposed, which is very commendable.

The fourth type is the rotating fan electrode, such as is used in the Vohr ozonizer, which has the advantage of quickly forcing the air through the generating field and ozonizing it at the same time, thus yielding a product of high purity. It is generally regarded as axiomatic that the briefer the period of ozonization the purer the resultant gas, purity meaning practically an absence of oxides of nitrogen, the formation of which is favored by heat, sparking or the presence of dirt.

The amount of nitrous oxide generated by any properly made type of air ozonizer, however, is so infinitely small that it can be totally disregarded. This statement, however, does not apply to all ozonizers.

The composition of normal air has recently been given in parts by volume per 1000 as follows: 769 nitrogen, 206 oxygen, 14 aqueous vapor, 9 argon, 0.33 carbon dioxide, 0.19 hydrogen, 0.008 ammonia, 0.0015 ozone and 0.0005 nitric acid. Authorities differ as to the amount of ozone in the air. It has been given all the way from 1 part in 1,000,000 by volume up to 1 part in 20,000,000. Perhaps a figure from 1 in 1,000,000 to 1 in 5,000,000 would represent what most have agreed upon as correct for those places where the presence of ozone is easily detected, so that the percentage of ozone in air given out by the best constructed ozonizers of later years has been in alignment with, or very little in excess of, the concentration which nature provides in localities remarkable for their invigorating air.

If a much higher density is used another factor must be relied upon to dilute the ozone to a point where it is agreeable to breathe—that is, the rest of the air in the room. This is unscientific because one is dealing with a factor outside of control, and the air currents of any room differ from those of every other. The machine that delivers the ozone with a continuous uniform concentration and with a controllable yield is built along sane, scientific lines.

Ozone can be condensed to a liquid state of a bluish color, with a specific gravity of 1.46. In this state it boils at about 120° C. Its density is 1 5/10 as compared with oxygen and 1 66/100 as compared with ordinary atmospheric air. It is slightly soluble in water and more soluble in certain oils. It reverts to oxygen at 270° C. It is unstable and rapidly disintegrates on standing. The loosely attached third atom is constantly tending to fly off and combine with other atoms as it has a remarkable affinity for all carbon or for compounds of carbon, which so far as ventilation is concerned may be referred to as organic matter.

Its value as an oxidizing agent is due to the ease of application and because nothing but oxygen is used in reaction. In the lighter concentrations its odor faintly resembles that of freshly bleached linen and is crisp, refreshing and exhilarating. It can be detected by the nose when present in one part to 10,000,000 of air. In the higher concentrations its odor is pungent, heavy and disagreeable.

Heat and humidity are unfavorable conditions for the generation of ozone. For this reason different methods have been employed to keep the electrodes cool. Steynis uses ammonia gas in pipes. Gerard uses oil. Others employ water jackets. The preferable method for air purification is the rapid passage of air by suction pumps or fans, such as are found in the Siemens & Halske later models in Germany and the Vohr model in the United States.

Any type of ozonizer where no mechanical means are provided for forcing the air rapidly past the electrode surface is considered to be utterly unreliable. In the first place, the air will remain for too long a period in the heat zone and thus produce an unsafe amount of nitrous oxide. Furthermore, such a type of generator is unscientific, as there are no means of obtaining either concentration or yield, since there is no regular air flow to measure by.

The amount of ozone generated is in direct proportion to the wattage of discharge per unit of air ozonized. Some element of heat is present in the so-called "cold" discharge, and this tends to destroy a portion of the ozone generated and

also destroys the theoretical accuracy of the above statement. Heat increases as the square of the current of discharge. It is, therefore, desirable to use a high voltage and low amperage and it has been found that from 8000 to 12,000 volts produce ozone with commendable economy.

Higher concentrations are needed for such purposes as water purification, the bleaching of fabrics, the destroying of disease germs, treating of petroleum oils, cyaniding (where with ozone it is now possible to get 94 per cent efficiency off the plates where in many instances only 60 per cent was obtained before), sterilizing infected rooms, ships, etc. For all of the above from 1 up to 12 grams per cubic meter is required. As high as 30 grams concentration has been obtained. High concentrations necessitate high wattage of electrical discharges per unit of air. Here the air passage must be slow, which, of course, results in low volume of ozonized air. The converse, of course, holds true that the more rapid the air flow the higher will be the volume of ozonized air, but the lower the density or concentration.

For all these large concentrations it is better to dry the air by the use of quicklime or other means, but for ventilating purposes it is not necessary to resort to this in the more recent types of ozonizers. One of the objections to extraordinary humidity is that an infinitely small amount of peroxide of hydrogen is liable to be formed.

The determination of the quantity of ozone generated is frequently obtained by using iodide of potassium solution. The iodine is freed by ozone, is acidified, then titrated by sodium thio-sulphite and starch.

The author then discussed at great length the chemical and physiological problems of air purification. What is the harmful part of bad air? Carbon dioxide in itself is not harmful. It is harmful only in that it reduces the oxygen supply by replacing it.

As long as one can get the proper percentage of oxygen in the air to breathe the amount of carbon dioxide produced in any chemical laboratory can be twenty times that which some engineers have put as a figure destructive to life. Carbon dioxide is not poisonous, but when present in considerable quantity in any air it is a danger sign that impurities exist in the air. However, it is a sign-board of danger only, not the danger itself. It is the organic impurities exhaled at the same time as the carbon dioxide that are poisonous.

Organic impurities come from a variety of sources. In all confined spaces the chief source of air pollution is the organic matter cast off through the pores of the skin and the nose, throat and mouths of the individuals occupying that space. The longer that matter which the body has cast off remains suspended in the air the quicker it deteriorates. When it reaches a putrescent state it is unfit to be rebreathed. This is air sewage or "crowd poison."

While ventilation is necessary to bring in out-of-door air to replace the oxygen which our breathing uses up outdoor air alone is absolutely insufficient to purify the indoor air. It never did and never will destroy the impurities that constitute the danger element. Nature purifies her atmosphere with ozone. Man can purify it only with ozone.

The author then sums up the use of ozone as a deodorizer. Its properties are remarkable in this line and with higher concentrations almost any odor known, excepting the extraordinary perfumery from the pole-cat, can be successfully combatted. In an office, factory or home the chief odors to be eliminated come from tobacco smoke, cooking, laundry, sick rooms or any overcrowded spaces.

The author records it is as the accepted opinion of many physicians that colds and kindred diseases come from bad air, chiefly because bad air disturbs that part of the nervous system which regulates the blood circulation and local blood congestion ensues, bringing with it an interference with certain bodily functions which destroy the bacteria constantly taken into the system. Thus infection occurs, lowering resistance to disease, and we start with colds which are frequently the forerunner of tonsilitis, bronchitis, pneumonia and even tuberculosis.

Ozonized air acts as a preventative of conditions which bring about many of our colds, and it is on the preventative rather than on the curative side that it has a serious claim to consideration. There is just as much and no more magic in ozone for continuous breathing purposes as there is in pure air. Pure air will help the body to cure itself and that is all that ozonized air in a concentration proper for breathing will do.

Abroad ozone as an air purifying agent and as a supplement to ventilation is being extensively used in factories, theaters, mines, ships, schools, hospitals, hotels, restaurants, gymnasia, offices, cold-storage houses, libraries and homes.

The use of ozone in the purification of air is undoubtedly one of the most valuable of the newer achievements of electrochemistry. First, as a preventative of conditions which undermine health; second, as a promoter of working efficiency, which involves the third, an increaser of business output, so that commercial and physical welfare are materially aided by a little boxed-up lightning placed in one's office, factory or home.

Evolution of the Lead Storage Battery.

A paper by Mr. PEDRO G. SALOM, of Philadelphia, dealt with the evolution of the lead storage battery. The first step was the Plante cell, with its great number of alternate charges and discharges, requiring weeks or months. Then came the Faure-Brush type of cell as the second step; that is, the cell with pasted active material and subsequent formation. Since 1881 no improvement has been made over this type except in mechanical details.

The logical evolution was to go a step further, to produce the active material in bulk outside of the cell and apply it mechanically to the grid, whereby the plate is finished and no subsequent formation is required. This is the "initially formed cell" of Mr. Salom, which is now being made by the Niagara Lead and Battery Company, of Niagara Falls, N. Y.

In our September issue, page 549, Mr. Salom's patent for this new cell has already been mentioned. The negative plate is made as follows: A mass of spongy lead is produced by electrolytic deposition or electrolytic reduction, thoroughly washed with cold water, passed under stirring or rubbing through a sieve of 40 mesh and is then exposed to the atmosphere and stirred to permit evaporation of the water. While the evaporation proceeds, a thin superficial coating of suboxide of lead is formed throughout the interstices of the spongy mass. For the success of the process it is of importance that this is stopped at the proper moment; this is indicated by the "feel" of the damp mass, which when squeezed between the fingers should have the "temper" of molding sand; it then contains still moisture, about 5 per cent in bulk of the total mass. In this state the superficially suboxidized spongy lead is applied to the grid and compressed within the compartments by means of heavy pressure (1,500 lb. per square inch). The finished plate presents smooth faces, flush with the thickness of the frame and main bars.

The chief advantages claimed for this new process of Mr. Salom over present practice are that the new plate, while remarkably homogeneous, carries a greater quantity of spongy lead and that the cost of producing the spongy lead electrolytically in bulk and applying it mechanically to the grid is less than the cost of an equivalent amount of litharge as employed in present practice.

Mr. Salom compared at some length in his paper the relative advantages of the Plante cell, the Faure-Brush cell, and the Salom initially formed cell. Quite a lively discussion followed.

Mr. Sperry said that in the popular mind the lead battery was something exceedingly heavy. But when a comparison was made concerning the amount of weight required to store

a certain amount of power it was found that the electric storage battery (an old type of cell being assumed in this calculation) required 80 lb. of total weight per hp-hour and a compressed-air system 212 lb. of total weight per hp-hour.

Mr. Hepburn gave 62 lb. per hp-hour as the corresponding figure for the Salom cell.

Mr. Salom stated that he does not know yet what the life of his negative plate would be. But experts have judged that it should last as long as the negative of the Plante cell, whose life is ten years. The capacity of the negative plate per ounce of active material is 2 amp-hours; that is, about four times the theoretically necessary amount of active material is used. This is about the same proportion as in other batteries. But Mr. Salom emphasized that he puts about 25 per cent more active material into his plate.

Mr. Hering remarked that a battery should not be judged by the figure of weight per hp-hour alone. Life is very important. And the most economical life should be found in the same way as for incandescent lamps, from these two factors: First, the depreciation of the battery, and, second, the cost of a new battery. A battery of shorter life and lower price may be more economical than one of longer life and higher price.

Mr. Hepburn emphasized the excellent and perpetually good contact between active material and support, which should insure a practically infinite life to the negative plate of the Salom cell. Under abnormal conditions the battery stands very well, and this is especially true for the negative plate. One important point in storage battery maintenance is never to allow the temperature to rise to too high a degree.

Mr. Sperry asked how the cell compared with the Edison iron-nickel cell and Mr. Salom gave for the Edison cell a specific capacity of 15 watts per pound of total weight, including everything. In this respect the Edison battery has an advantage over the lead cell, for which Mr. Salom does not claim more than 10 watts per pound. But Mr. Salom said that the claims, sometimes made for the Edison battery, of 100 per cent greater watt-hour efficiency were not justified, as it was only 10 or 15 per cent greater.

Dr. Edward Gudeman emphasized that for certain purposes the available space was a consideration and that the figure of power per volume should be given besides the figure of the power per weight.

Self-Discharge of Batteries.

A paper on the self-discharge of Plante and Faure storage batteries by Prof. O. W. Brown and Mr. W. G. Bowers was then presented. Comparative tests were made with four different types of batteries: (1) Both plates pasted, (2) both plates Plante, (3) both plates Plante, but more deeply formed, (4) positive Plante and negative pasted plate. The results of the comparative tests are summed up as follows:

The Plante type of cell looses its charge when allowed to remain on open circuit for periods of ten to twenty days. The Brush-Faure cell, when made from pure materials, suffers only very slight loss in capacity when left on open circuit; and in every test the self-discharge of the Brush-Faure cell was much less than that of cells of the Plante type.

The data also shows that the Plante cell suffers permanent injury when considerable periods of time are allowed to elapse between charges; while one or two recharges of a Brush-Faure cell restore it to its original capacity.

In the light of these results the Brush-Faure cell is best suited for all service where intervals of a week to a month or more must elapse between charges. This condition is found in some telephone plants, in isolated lighting plants and where cell are used for ignition purposes and for signal systems.

Overvoltage Phenomena.

Mr. Carl Hambuechen, of the Northern Chemical Engineering Laboratories, of Madison, Wis., presented a paper on the practical significance of overvoltage phenomena.

The overvoltage of a certain metal is that excess voltage which is required for the setting free of hydrogen gas at a cathode of the given metal, as compared in general with a hydrogen electrode (platinized platinum electrode covered and saturated with hydrogen gas). Under otherwise the same conditions a higher potential is required to set hydrogen free at some metallic plates than at others. Hydrogen shows a decided aversion to tin and lead and zinc, as shown by the higher voltage required to set hydrogen free on these metals.

Mott gives the following list of overvoltages of hydrogen on the various metals:

Tin	.55 volt
Lead	.50 "
Antimony	.45 "
Bismuth	.45 "
Gold	.20 "
Silver	.15 "
Platinum	.15 "
Iron	.10 "
Copper	Reference standard
Brass	.14 volt.

Neumann in his table of electrochemical potentitls of various elements making contact with electrolytes gives the following values of elements against normal chloride solutions:

Aluminium	+ 1.015 volt.
Zinc	+ .503 "
Cobalt	— .015 "
Nickel	— .020 "
Tin	— .085 "
Iron	— .087 "
Lead	— .095 "
Hydrogen	— .249 "
Bismuth	— .315 "
Copper	— .5+ "
Platinum	— 1.140 "
Gold	— 1.356 "

According to the generally accepted theory, the corrosion of metals is caused by galvanic couples due to impurities or electronegative elements in the metal under consideration, and the rapidity of corrosion will then be dependent principally upon two factors, the resistance of the local circuits and the electrochemical voltage. If the latter were the only factor governing the motive force which sets up the current we could use the Neumann table of single potentials as a guide to tell just how bad certain combinations of metal are from the corrosion standpoint. Thus we would know that zinc containing particles of copper would be subject to corrosion couples of 1.003 volts, zinc with iron .59 volt, zinc with tin .588 volt, etc.

However, there is another important factor, namely, the overvoltage values; the active galvanic couples always give rise to the liberation of hydrogen on the electronegative or cathodic particles and therefore the overvoltage values must be considered.

Thus, a couple of zinc and copper would have the value approximately as above given, 1.003 volts, because hydrogen on copper has very slight overvoltage; zinc with iron would have, not the value .59 volt, but .1 volt less, or .49 volt effective pressure; and zinc and tin would have .558 less .55 volt (the overvoltage of tin) or .038 volt.

While the electrochemical potential table would indicate that tin is as bad an element as is iron for producing corrosion on zinc, the correction for overvoltage shows that tin is far less harmful. And this is borne out by the facts in various practical instances. It is a matter of practical knowledge that iron or copper introduced as an impurity in dry cells is very harmful, producing rapid deterioration, while lead and tin (having high overvoltages) are almost harmless. This is fortunate, as otherwise the solder for making the seams

would have to be prevented absolutely from entering the container and making contact with the electrolyte. The dry cell construction would be therefore more difficult and expensive.

A well-known household method of cleaning silverware of tarnish consists in placing the silverware in a zinc vessel containing an electrolyte such as baking soda and salt. The tarnish is removed by electrochemical reduction—the zinc acting as anode and the silver surface as cathode. In studying this process the writer noticed that a zinc vessel having been used thus a few times lost its effectiveness due to the formation of a high-resistance film on the zinc surface which prevents the silverware from making electrical contact therewith when resting upon it.

It was found that a grating of tinned iron wire soldered to the zinc entirely prevented this difficulty. The tin acting as the cathode surface is always maintained bright and chemically clean, and due to the overvoltage of tin this is kept clean at the expense of a minimum amount of current. Then, when the silverware is placed upon such tinned grating, it cannot avoid being placed in electrical contact, and the current generated by the dissolving of the zinc is concentrated upon the silver to the practical exclusion of the tin.

In the making of electrical contacts the usefulness of tin is well known, and this is dependent largely upon its high overvoltage.

Zinc is employed extensively as a means of preventing boiler corrosion. It is an old remedy and is effective when properly employed. The principal difficulty in the use of zinc is that it must be attached firmly to the iron or other metal structure which it is designed to protect so as to insure electrical contact. The protection is effected at the expense of the zinc, which is corroded, and which must be replaced from time to time. It is evident that in the interior of a boiler it is difficult to introduce zinc, and it appears that the overvoltage of tin may be called into play in this connection.

As an example of the various methods in which this might be employed, the following is mentioned. Through the boiler which is to be protected is passed an iron rod or tube coated with a layer of tin. This rod is bolted to the boiler shell in such a way as to make electrical contact. This tinned tube forms with the iron of the boiler a galvanic couple which would be detrimental to the boiler if it were not for the overvoltage which is set up by hydrogen on the tin. From this tinned rod may be suspended plates or chunks of zinc by means of a tinned stirrup. The exposed tin always acting as a cathode will be kept clean and therefore be capable of making electrical contact. A convenient form in which to employ the zinc is in rings of zinc coated on the inner surface with tin or solder and slipped over the tinned rod. This can be readily provided for by stuffing boxes or hand holes through which the tinned rod is passed. The worn-out zinc pieces can be thus removed and new zinc introduced.

Mr. Mott has already pointed out the desirability of studying overvoltages of the various metals in connection with the investigation of corrosion phenomena; that an alloy consisting of two elements widely separated in the electrochemical series may not necessarily be a corrodible alloy if the negative element possesses a high overvoltage.

Mr. Hambuechen concludes that in studying corrosion we are concerned not only with the contact potential and the overvoltage of the individual elements constituting an alloy, but the study must be extended to include the single potential and overvoltage of the alloying compounds. Thus, for example, it has been found that brass has an extremely low overvoltage, lower than either copper or the zinc of which it is composed. This is undoubtedly due to the fact that the brass is composed of one or more alloying compounds.

Metallic Food Containers.

The first paper of the Saturday morning session was presented by Dr. EDWARD GUDEMAN, of Chicago, on the corrosion of metallic food containers.

The powers in food chemistry have come to the viewpoint of considering a quantity of 0.001 per cent as a large quantity. Food products are sometimes condemned for very small quantities of impurities.

This is of importance in connection with the use of tinplate for food containers. Until recently there has been no objection to tin. But now the Department of Agriculture requires that food must not contain more than 300 milligrams of tin per kilogram. This is the permissible maximum.

When food ages it undergoes decomposition. Sulphuretted hydrogen and carbonic acid are set free. Carbonic acid attacks, for instance, lead rapidly. There may be, in general, oxidation, reduction, action of acids, and action of alkalies.

The solubility of tin is small. But a complete uniform covering of an iron plate with tin without pores is impossible. Dr. Gudeman has made a series of experiments to produce some continuous coverings which will not be corroded and will not be attacked by the food product.

He first experimented with coatings of gold on iron. These can be made continuous, and the gold film may be made so thin that the cost of the gold itself is not prohibitive. The iron plate is treated with an amalgam of gold and mercury and the mercury is distilled off. The process is workable, but 98 lb. of mercury are to be distilled off for 2 lb. of gold. This indicates the inherent difficulties of the process.

He then tried to enamel iron plates. But the enamel should not be applied simply to the outside of the iron plate, as it might crack off; the enamel must be made an integral part of the iron plate. Dr. Gudeman forced enamel into iron by high pressure, some 5000 to 8000 lb. per square inch. The excess of enamel was taken off and the plate heated to fuse the enamel to the iron. Enameled iron plates, prepared in this way, have in fact withstood the action of boiling sulphuric acid and of boiling alkali better than Jena glass.

The question then presented itself to Dr. Gudeman: if real enamel can be fused onto iron plate, why not impregnate iron plate with glass? This can be done. Such a glassed iron plate withstands the dissolving action of food as well as glass. But a fusible glass is needed. This means lead glass. But lead is not wanted in the food. Thus all difficulties have not yet been solved. Dr. Gudeman is continuing his researches.

The Electric Furnace in Metallurgy.

A paper by Mr. MARCUS RUTHENBURG, of London, England, was then presented on "The Electric Furnace and Its Applications." He briefly traced its history from the first electric furnace built by Siemens thirty-five years ago.

Direct current is required only if an electrolytic action is to be performed in the furnace, as in the manufacture of aluminium. Alternating current is preferable for all electric furnaces where only a heating effect is to be produced.

While most large electric furnaces are operated at constant voltage, it is advisable to consider constant-current operation.

There is a considerable waste of electrodes and this represents a great expense. This waste of electrodes is not all at the ends but also at the sides. Water-jacketing the electrodes is very useful.

To use slag as a conductor of heat is also recommended to save the electrodes.

Mr. Ruthenburg then reviewed various applications of the electric furnaces in metallurgy, especially for the treatment of:

Nickeliferous iron ores;

Complex lead-zinc-iron ores, in the smelting of which lead and zinc are volatilized and condensed outside;

Tin ores;

Ores of tungsten, manganese, etc.

In conclusion, Mr. Ruthenburg referred to the importance of cheap power supply. He uses himself current from a steam plant which is charged at 0.22 cent per kw-hour.

In the brief discussion which followed Mr. F. T. Snyder spoke on the possibility of central stations supplying electrical

energy to electric furnace plants at a reduced rate at times of light load. He questioned the practicability of such schemes, as the usual electric furnace was not generally a useful load for the central station.

Electrostatic Ore Concentration.

Mr. F. S. MacGregor presented a paper on "Applications of the Electrostatic Separation to Ore Dressing," with special reference to the new system of the Huff Electrostatic Separator Company, of Boston, Mass. (see also page 295 of our May issue). The commercial application of the art of electrostatic separation has been tried a number of times within the last decade, but until only within about three years has success attended the efforts.

Two factors contributed to this want of success—a lack of the proper means of continuous electrification, and a practical machine and system of treatment designed to meet the rigorous requirements of mill operation. Recognizing these conditions, the Huff Electrostatic Separator Company, of Boston, has perfected several types of separators and a means of electrification which have been a commercial success from their first installation, and at present the entire concentrating and separating machinery of two plants consists of Huff separators—one located at Platteville, Wis., owned by the American Zinc, Lead & Smelting Company, and the other at Midvale, Utah, owned by the United States Smelting, Refining & Mining Company. Also a plant is being installed in Nevada.

The type of machine is shown in Fig. 3 and consists of a series of separating electrodes placed one above the other. The frame is cast iron, built in sections, with two electrodes to each section, which facilitates easy shipment and also flexibility in the number of treatments which can be given the ore, and which is dependent on its requirements. A three-section machine (the usual type) is 6 ft. high, 6 ft. 6 in. long and 18 in. wide. A feed hopper on the top distributes the ore across the first electrode, and it passes by gravity to each succeeding one. The mineral particles receive their charge while passing through a concentrated static field formed by two electrodes—one a grounded rotated shaft and the other an insulated metal rod.

The electrostatic charging of the electrodes is accomplished by a special electrical apparatus (using commercial dynamos and transformers), which, with no more than the usual oiling, gives either a continuous and steady potential of several thousand volts, or an intermittent or pulsating charge of great regularity. The potential, or strength of the field, can be altered at will, according to the conductivities of various ores

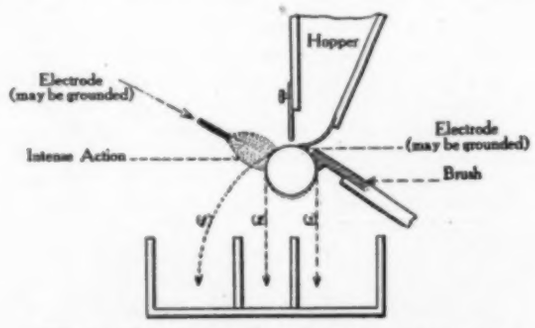

FIG. 2.—PRINCIPLE OF ELECTROSTATIC SEPARATION.

treated. Fig. 2 shows the scheme of separation, the dotted lines indicating *in general* the path of the conductors and non-conductors.

The separating plant at Platteville was started in March, 1908, and was the first plant to be equipped with Huff separators. Although originally built as an experimental plant, it has been in practically continuous operation since then, and used to separate, without roasting, the iron pyrite from the zinc blende, which occur together in varying proportions in southwestern Wisconsin. The ores are milled in ordinary jigs and the lead and lime rock removed. Owing to the nearness in specific gravity of the blende and pyrite, they are recovered in the jigs as a middlings, containing from 10 to 45 per cent zinc, according to the grade of the crude ore, the remaining percentage being iron and the sulphur in combination. Iron above a few per cent interferes with the smelting of the blende, and the function of this plant is to remove this pyrite, making the low-grade ores into high-grade smelting ores.

The plant consists of a wooden, frame building, 9 x 12 m (30 x 40 ft.), and three stories high. On the first floor are

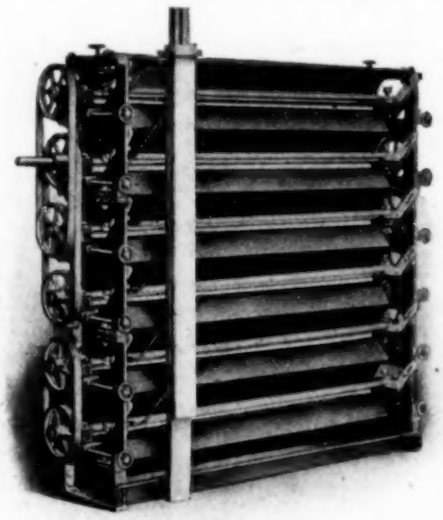

FIG. 3.—ELECTROSTATIC SEPARATOR.

the bins for collecting the finished products as they are delivered from the separators. The second and third floors are separator floors, and in the tower is located the screening system. A spur railroad track runs on either side of the mill, one for cars of raw ore, allowing them to be unloaded either directly into the mill or into storage bins across the track. The other track, which is below the mill level, permits at the same time the loading of empty cars with finished products.

The course of the ore through the plant is as follows: It is shoveled into a wheelbarrow in the freight car, wheeled to scales and weighed, then dumped into the feed hopper of the dryer. The top of this hopper is on a level with the car floors to facilitate easy handling of the ore, and at the bottom of this hopper is an adjustable plunger feeder. The dryer is of the cylindrical type, and the shell is 5 m (16 ft.) long and 0.75 m (30 in.) in diameter, rotating about 4½ r.p.m. Being set at a slight pitch, the ore travels gradually to the discharge end, where it emerges bone-dry. As the separation depends on the difference in conductivity of the minerals it is necessary that all moisture be removed.

A short drag conveyor carries the dried ore to the foot of a bucket elevator, which raises it to the top of the tower and discharges it into a set of screens. There are four, giving an oversize and four other sizes, called A, B, C and D. In general the sizes are as follows:

A	size.....	6	x	5	mesh.	(7 x 8 mm)
B	"	10	x	7	"	(4 x 6 ")
C	"	24	x	20	"	(0.16 x 0.20 ")
D	"	50	x	50	"	(0.08 x 9.08 ")

The oversize passes through a short trommel to remove any foreign materials, and is spouted to the first floor to a set of rolls, which crush it and deliver it to the boot of the elevator carrying the original feed.

The location of the screens in a tower permits the different sizes to flow by gravity through iron pipe 5 cm (2 in.) diameter to the top machine floor. On this floor are located

the rougher machines, where the ore is given a rough split, that is, two products are made, one a product higher in zinc than the original feed, and the other higher in iron. Thus, no matter what the grade of the feed to the mill may be (and it varies within wide limits), a fairly uniform mixture is sent to the finishing machines on the floor below.

These finishing machines give the final cleaning to the ore, one set giving a finished iron product, and the other a finished zinc product. The middlings from these cleaners return by gravity to the boot of the elevator and mix with the fresh ore, so that no ore leaves the system that is not separated into its proper grades of product.

The finished zinc product and finished iron product fall into separate bins on the first floor. These bins are V-bottomed, and constructed of two thicknesses of wood flooring with heavy building paper between. They are elevated from the floor so that they may conveniently be drawn off into a 730-kg (1600-lb.) capacity push car for loading.

The car is then wheeled to a small elevator and dumped into a hopper on the floor level. This feeds the ore into the boot of a small elevator, which discharges either into a freight car by means of a goose-neck spout, or may be allowed to discharge to a second elevator in the storage bins. From these bins a car may be loaded whenever convenient.

The plant generates its own power, and the engine and boiler rooms are located in an adjoining building. The fire-boxes of the boiler and dryer are side by side, enabling the engineer to look after both fires as well as the engine room. Power is supplied by a Corliss engine connected to the mill by a clutch.

The plant operates continuously three shifts per day. The labor required per 24 hours is as follows:

3 shift bosses	(8 hours each)
3 machine helpers	(8 " ")
3 dryer feeders	(8 " ")
2 loaders	(10 " ")
2 engineers	(13 and 11 hours each)

There are also a superintendent, master mechanic, assayer, one buyer and bookkeeper, although the buyer and, to a large extent, the assayer devote their time to obtaining custom work.

Two products of marketable value are obtained: The iron pyrite, hitherto valueless in these Wisconsin ores, is sold for its sulphur content, and by reason of its free-burning qualities, makes a very desirable product for the acid manufacturer; and a zinc product which is, of course, sold for spelter. The pyrite is sold by contract, but the blende is sold to the smelters on the open market. With a penalty for excess of iron or lead, one may see it is necessary for such a plant to turn out consistently high-grade products in order to command a satisfactory market price.

The results taken from the "Record of Shipments" for a month show an average zinc product of 55.2 per cent Zn and 3.4 per cent Fe, and a pyrite product of 3.7 per cent Zn and 44.7 per cent S. The average zinc content of the ore, bought and separated into the above products, was 24.1 per cent Zn, and the average iron content was 25.4 per cent Fe. The minimum zinc content was 6.7 per cent Zn, and the maximum 41.2 per cent Zn. The high grade of the separated products shows the flexibility of the process and the ability of the plant to handle any grade of ore from the district.

As a result of the excellent showing of this electrostatic plant the United States Smelting, Mining & Refining Company decided to put in a plant at their works at Midvale, Utah. The function of an electrostatic plant there is different from that in Platteville, for the ore from the mine of the United States company at Bingham, Utah, contains about 9 per cent of zinc in addition to the gold, silver and lead values.

This ore is shipped to the concentrator at Midvale, where it is crushed and milled by the usual methods of jigs and tables. In this concentration there were formerly two products, one a lead-pyrite product carrying the iron and considerable zinc, and a tailings carrying zinc and some gold and silver values, the object being to keep the zinc as low as possible in the lead concentrate, and yet at the same time make the maximum recovery of the gold, silver, lead and copper values. The zinc added materially to the difficulty and cost of smelting the lead concentrates, and, at the same time, was a total loss. In order to recover this zinc three products were made of the concentrator, a lead-pyrite carrying practically no zinc, tailings free from zinc and middlings containing about 22 per cent zinc, the balance pyrite and some copper, lead, gold and silver.

To treat these middlings an electrostatic plant was built near the concentrator, as shown. It is a wooden frame building 12 m x 12 m (40 ft. x 40 ft.), and covered with corrugated sheet iron. In general plan it is the same as the Platteville plant—finished ore bins on the ground floor and two floors of separators.

The method used for handling the ore is somewhat different. The middlings are shoveled from the table hutches in the wet concentrator into tramcars, which are pushed by hand to the platform elevator at the electrostatic plant. The cars are raised to the third floor level, and, after weighing, are dumped into a 40-ton hopper. This is built over the dryer and feeds automatically. After drying the ore is screened as follows: Making A size 12 on 24, B size 24 on 50, C size through 50 mesh.

The oversize is small in amount and very low in zinc, so, instead of re-crushing, it is put directly into the finished pyrite. The three sizes, A, B and C, are separated, and the products drawn from the bins on the first floor into tramcars. These are run out of the mill to the loading trestle and dumped into freight cars. The pyrite product is smelted in the United States smelter nearby, and the zinc product is shipped to the Kansas zinc smelters.

The plant is electric driven by a 20-hp motor, the 15 Huff separators requiring about ⅛ hp each. The generating apparatus for the electrostatic field is located in a small room on the finishing floor. A 3-hp motor is direct coupled to a generator, and the strength of field is controlled from a small switchboard.

The plant is being operated in conjunction with the concentrator, and the superintendence, assaying and bookkeeping are taken care of by the smelter staff.

The average assays of the feed and products are as follows:

	Au.	Ag.	Cu.	Pb.	SiO_2	Fe.	Zn.	CaC
	Oz. per Ton.							
Crude ore to concentrator	0.08	3.8	0.41	8.4	28.8	14.3	9.0	6.0
Middlings to electrostatic plant	0.05	2.8	1.11	3.3	4.6	24.3	21.6	1.9
Finished pyrite	0.14	4.8	2.24	6.6	..	26.0	9.0	..
Finished blende	0.02	1.5	0.61	2.0	..	3.6	52.9	..

This electrostatic plant not only removes the objectionable zinc from the lead-pyrite concentrate, but makes of it a marketable product, and, instead of being a total loss, it is made to produce a profit. The electrostatic process in these two plants demonstrates two applications in ore dressing, one the custom plant making low-grade ores profitable and the other as an adjunct to a wet concentrator for the recovery of zinc.

Besides these plants, there is being installed in Nevada a plant working on crude silver ores, wherein the ore goes through no concentrating machinery prior to its electrostatic treatment. The process has been proved applicable to many special problems, such as the concentration of copper and lead-silver ores in heavy gangues, such as garnet, braite, epidote, etc.

The table on page 638 will give some idea of what can be expected with several of these problems.

The perfection of the art of electrostatic separation marks an important step in the dressing of complex or difficultly milled ores.

In the brief discussion which followed Mr. MacGregor explained that the capacity of the electrostatic separator depends on the size of the ore and the character of the ore. At Platteville 15 machines treat 95 tons a day.

TABLE OF ELECTROSTATIC SEPARATIONS

Material	Product	% Cu.	% Fe.	% Pb.	% Zn.	% SiO_2	Oz. Au.	Oz. Ag
Low Grade Chalcopyrite in Quartz	Original	2.56	17.8	....	....	....	0.01	2.6
	Concentrates	5.63	37.0	....	....	....	0.02	5.5
	Tails	0.10	2.0	....	....	....	Trace	0.4
Pyrite and Chalcopyrite in Various Gangues	Original	6.37	25.0	....	....	....	....	....
	Concentrates	9.33	36.3	....	....	....	....	....
	Tails	0.14	1.9	....	....	....	....	....
Chalcopyrite and Bornite in Garnet	Original	3.60	18.6	....	....	32.3	(Iron partly	
	Concentrates	19.10	25.7	....	....	14.4	in Sulphide	
	Tails	0.34	17.6	....	....	36.7	and partly in Garnet.)	
Zinc, Iron, and Silver Ore	Original	2.61	23.8	13.9	19.4	....	....	52.8
	Concentrates	3.33	30.7	16.4	6.4	....	....	69.0
	Tails	0.91	3.4	2.7	51.8	....	....	4.6
Zinc, Lead, and Iron Middlings	Original	....	20.2	12.6	23.1	5.2	....	....
	Concentrates	....	31.2	21.0	4.0	3.2	....	....
	Tails	....	2.4	0.5	53.8	8.5	....	....

Material	Product	% Cu.	% Fe.	% Pb.	% Zn.	% S.	% SiO_2
New Mexico Concentrates	Original	2.11	16.2	.....	29.9	.....	12.9
	Concentrates	5.65	37.2	.....	4.9	.....	6.6
	Tails	0.13	4.2	.....	44.9	.....	15.9
Zinc from Above Tailings	Original	.....	.....	.....	.....	.....	.....
	Concentrates	.....	.....	.....	57.1	.....	.....
	Tails	.....	.....	.....	1.3	.....	.....
Native Copper in Sandstone	Original	2.68	.....	.....	.....	.....	.....
	Concentrates	38.70	.....	.....	.....	.....	.....
	Tails	0.27	.....	.....	.....	.....	.....
Pyrite Concentration for Sulphur	Original	.....	.....	.....	.....	30.1	.....
	Concentrates	.....	.....	.....	.....	44.8	.....
	Tails	.....	.....	.....	.....	3.0	.....
Middlings from Joplin, Mo.	Original	.....	10.8	2.5	49.5	.....	.....
	Concentrates	.....	37.4	9.9	2.9	.....	.....
	Tails	.....	1.6	Trace	62.3	.....	.....

Isolation of Ions.

Prof. Robert A. Millikan, of the Ryerson Physical Laboratory of the University of Chicago, presented a paper on the isolation of an ion and a precision measurement of its charge. The principle of the method is to hold a given small droplet of oil (or other non-volatile substance) under observation for a considerable time, which may be four or five hours, and to watch its movement both under the action of gravity alone and under the combined action of gravity and an electrostatic field, and to watch especially the changes of this movement which occur when the droplet catches ions from the air.

Oil is sprayed through an atomizer so that it can be obtained in minute droplets, and one of these droplets is admitted into the air space between the horizontal plates of an air condenser charged from a storage battery to any voltage up to 12,000 volts.

The oil droplet is so small that it almost floats in the air. It descends very slowly under the action of gravity. The motion of the droplet is observed through a telescope and its speed carefully measured. This is first done while the condenser is not charged, so that the electrostatic field is zero and gravity acts alone. The speed is also measured while the condenser is charged so that both the electrostatic field and gravity act on the oil droplet. From both measurements the charge carried by the oil drop can be found.

Now while the oil droplet is under observation, it is liable at any moment to catch one of the ions which normally exist in air or which have been produced in the air between the plates by some ionizing agent. In that moment the speed under the influence of the electrostatic field changes immediately, while the speed under action of gravity alone remains constant. From this change of speed the charge of the new ion which has been captured by the oil droplet is determined.

For the calculation of the charge only very simple mathematics is required and no assumptions whatever are necessary except that Stokes' law holds good. This is found to be correct as long as the oil droplet is not too small. For sizes of the droplet below certain limits it must be modified, but it is remarkable that the modification which was found to be necessary by Professor Millikan from his experimental results agrees exactly with a curve formerly derived and based on a purely theoretical argument.

The chief results which follow from the very extended series of Professor Millikan's determinations are as follows:

The charge of any ion, whether positive or negative, which is captured at any time by the oil droplet is always a multiple of 4.9×10^{-10} c.g.s. units. Further the charge carried originally by the oil droplet is also always a multiple of the same quantity of electricity.

In other words, we have something entirely analogous to the chemical combination of elements according to definite multiple proportions. The conclusion is that electricity is atomic or ionic, or granular, or corpuscular in structure. All charges are built up of elementary unit charges or ionic charges. The elementary or ionic charge is 4.9×10^{-10} c.g.s. units. The measurement of the ionic charge by this method is directly comparable with atomic weight determination.

In the brief discussion which followed all the speakers complimented Professor Millikan highly on the fundamental character of his work and the astonishing accuracy obtained. Dr. Schlundt referred to the doubtful results recently obtained by Ehrenhaft with a somewhat similar method and asked whether his troubles could be attributed to his using too small droplets. This was confirmed by Professor Millikan, who said that Ehrenhaft had worked with particles 10 or more times smaller than his (Millikan's) droplets and that for such small sizes Stokes' law ceases to hold at all. The apparatus used by Professor Millikan was afterward shown and demonstrated by him in the Ryerson Laboratory of the University of Chicago.

Crystallization Through Membranes.

A paper by Dr. J. H. Walton, Jr., of the University of Wisconsin, dealt with the phenomena of crystallization through membranes. It was presented in abstract by Dr. Kahlenberg. Two parts of a vessel were filled with the same supersaturated (under-cooled) solution and separated from each other by a membrane. By dropping a small crystal into the solution on one side, crystallization was started on this side. The question was whether the crystallization would pass through the membrane to the other side. This was the case with some solutions and some membranes, but not with others. The experiments required utmost care. There seems a connection with adsorption phenomena and the whole matter is of great importance with respect to semipermeable diaphragms which have played such a big rôle in the development of Van't Hoff's theory of solutions.

Relative Basicity of Metals.

Dr. Louis Kahlenberg, of the University of Wisconsin, then presented his paper on the relative basicity of metals as shown by their power to replace one another in chemical compounds.

In the past all the work has been done with the aqueous solution and a series of the metals has been determined according to their potentials in aqueous solutions or their ability to replace one another in aqueous solution. The object of Dr. Kahlenberg's research was to determine how the situation is in solutions where there is no water and whether metals can replace one another in insulating liquids.

Dr. Kahlenberg experimented with some 60 different solvents and found that the series of the metals had an entirely different order in non-aqueous solutions from that in aqueous solutions. In many cases a tremendous power of lead to throw out copper was apparent. Thus copper is thrown out by lead from a copper oleate solution. The series of the metals in carbon bisulphide solutions is as follows: Pb, Zn, Bi, Mg, Co, Sn, Fe, Al, Ag, Sb, Ni, Hg. This series is considerably different from the series for aqueous solutions.

It is also a fact that in these solutions which are practically non-conductors reactions are quite as instantaneous as in aqueous solutions. It is, therefore, a fact that the replacement of one metal by another does not depend on the electric conduc-

tivity of the solution. In some cases the solutions had to have a definite concentration if the throwing out of the metal was to be complete.

In the discussion which followed, Dr. Richards pointed out that in aqueous solutions the series followed in general the order of the heats of formation. Dr. Kahlenberg said that he did not yet know whether the same was true for non-aqueous solutions. The thermochemistry of non-aqueous solutions is now being taken up systematically at the University of Wisconsin. The above observations may offer possibilities for practical use to throw out strong metals by weak ones.

Water in Chemical Reactions.

A paper by Dr. DAVID KLEIN, of the University of Wisconsin, dealt with the effect of water in causing chemical reactions. It was read in abstract by Dr. Kahlenberg.

It has been claimed that for many chemical reactions to go on the presence of water is absolutely necessary, and that in this respect water is unique. For instance, hydrogen sulphide and sulphur dioxide will not react when no water is present. Dr. Klein made experiments with 25 other substances than water and found that 15 of them were as effective as water. The Nernst-Thomson rule does not hold. There is chemical activity in electric insulators. "Wasser ist kein besonderer Saft."

These last three papers form part of the extended research work which is being carried on at the University of Wisconsin under direction of Professor Kahlenberg.

After a hearty vote of thanks to all those in Chicago who had contributed to the great success of the first Western convention of the Society, the meeting adjourned. The next meeting will be held in spring, 1911, in New York City, when the new magnificent building of the Chemists' Club will be ready.

In the following we give a complete alphabetical list of the names of members and guests in the last printed registry list. Where no city is stated, Chicago is meant.

T. B. Allen, Niagara Falls, N. Y.; R. L. Ardrey, W. H. Arison, Niagara Falls; Mr. C. B. Askew, Chas. F. Baker, Wm. C. Bauer, Evanston, Ill.; Mr. and Mrs. A. Bement; P. McN. Bennie, Niagara, Falls; M. Bentley; E. J. Berg, Urbana, Ill.; O. N. Berndt; Wm. Bjorkstedt, Gary, Ind.; David J. Block; F. H. Bosworth; Dr. and Mrs. Wm. Brady; Ivan M. Bregowsky; Morgan Brooks, Urbana, Ill.; John W. Brown, Cleveland, Ohio; A. F. Brunck; T. J. Bryan, Oak Park, Ill.; C. F. Burgess, Madison, Wis.; Wm. W. Burson; J. A. Cameron; T. M. Caven; E. S. Clarage; E. L. Clark, Cleveland, Ohio; Jesse Coates, Coatesville, Pa.; W. W. Coghill, Evanston, Ill.; H. B. Coho, New York; F. L. Collins; R. T. Conger; H. R. Connell, Pittsburgh, Pa.; Wm. A. Converse; G. W. Conway; T. M. Craven; J. S. Crider, Cleveland, Ohio; R. A. Crider, Cleveland, Ohio; C. W. Danforth, Gary, Ind.; G. M. Davidson; Mr. F. M. de Beers; J. C. Dickerman; H. E. Diller, Schenectady, N. Y.; W. W. Dingee Ervin Dryer; J. A. Ede, La Salle, Ill.; H. Ehrlich; H. H. Engle, Cleveland, O.; W. F. Faragher; S. H. Fleming, Cleveland, Ohio; Geo. E. Folk; W. S. Ford; F. F. Fowle; K. G. Frank, New York City; F. C. Frary, Minneapolis, Minn.; A. E. Gibbs, Wyandotte, Mich.; Miss M. E. Gibbs, Wyandotte, Mich.; J. H. Goodwin, Fremont, Ohio; B. E. Grant; W. H. Graves; Albert E. Greene; J. B. Greene; W. B. Greenlee; Edw. Gudeman; Carl Hambuerhen, Madison, Wis.; M. E. Hanna; M. H. Hanks; G. W. Heise; H. A. Heise; Miss Alice Henderson, Green Bay, Wis.; D. M. Hepburn, Niagara Falls, N. Y.; Carl Hering, Philadelphia, Pa.; Paul Heroult, N. Y. City; W. T. Holmes, Baltimore, Md.; R. Hornbeck, Livingston, Mont.; Mr. and Mrs. Wm. Hoskins; W. C. Hovey; L. E. Howard; Mr. and Mrs. Alois von Isokovics, Monticello, N. Y.; E. C. Hulbert; Mrs. J. H. Jackson; G. J. Jenista; A. R. Johnson; Grinnell Jones, Urbana, Ill.; G. H. Jones; L. Kahlenberg, Madison, Wis.; Chas. C. Kawin; W. E. Keily; A. Keller, Milwaukee, Wis.; W. M. Kelsey, De Pue, Ill.; Philo Kemery, Pittsburgh, Pa.; E. T. King, Cleveland, Ohio; W. W. Kinsley, Jr.; Geo. O. Knapp; Otto Kney; M. M. Kohn, N. Y. City; Wm. Koula; O. L. Kowalke, Madison, Wis.; G. Lawson; W. Leeds; F. A. Lidbury, Niagara Falls; C. B. Lihme, La Salle, Ill.; O. Linder; M. G. Lloyd; J. A. Lounsburg; F. H. Loveridge; A. Lowenstein; Ernest Lunn; Mr. and Mrs. James Lyman; W. P. Marseilles, Niagara Falls, N. Y.; Mr. and Mrs. A. B. Marvin; Mr. and Mrs. H. T. Matthews; G. M. Mayer; Miss Eleanor Mayher, Easthampton, Mass.; F. S. MacGregor, Boston, Mass.; Harry McCormack; Dr. and Mrs. H. N. McCoy; J. E. McCullough, Maywood, Ill.; P. C. Messinger; J. M. Morehead; J. M. Muir, N. Y. City; P. J. Myall; F. J. Newman; F. J. O'Byrne; O. A. Olson; Chas. G. Osborne; Geo. S. Page, Pittsburgh, Pa.; H. Pagenstecher; J. H. Parker, Reading, Pa.; H. F. Pfaff; A. C. Parsons, Buffalo, N. Y.; C. R. Pierce; W. B. Pietz, Cleveland O.; H. F. Plaff; B. G. Poucher; H. C. Quigley; Albert A. Radtke; A. G. Reeve, Niagara Falls, N. Y.; J. B. Replogle; Edward T. Rice, Schenectady, N. Y.; Jos. W. Richards, South Bethlehem, Pa.; Dr. and Mrs. W. D. Richardson; E. F. Roeber, New York City; O. E. Ruhoff, Madison, Wis.; F. C. Ryan, Hammond, Ind.; P. G. Salom, Philadelphia, Pa.; L. E. Saunders, Niagara Falls; M. Scharitz; C. J. Schwarz; R. C. Schwarz, Rochester, N. Y.; W. V. Schenck; Herman Schlundt, Columbia, Mo.; W. B. Schulte, Madison, Wis.; J. A. Seede, Schenectady, N. Y.; R. D. Small; E. S. Smith, Niagara Falls, N. Y.; W. R. Smith; Edwin H. Smythe; Mr. and Mrs. F. T. Snyder; J. L. K. Snyder, Cleveland, O.; M. A. Spencer, Jackson, Mich.; E. A. Sperry, N. Y. City; E. C. Sprague, Niagara Falls; S. E. Stafford, Pittsburgh, Pa.; F. Mc. M. Stanton, N. Y. City; W. M. Stein, Philadelphia, Pa.; Geo. W. Sternbergh; Leland L. Summers; J. A. Sutherland; C. J. Swartz; Mr. and Mrs. E. R. Taylor, Penn Yan, N. Y.; E. C. Taylor, Penn Yan, N. Y.; Miss E. B. Taylor, Penn Yan, N. Y.; B. F. Thomas, Chattanooga, Tenn.; C. B. Thwing, Philadelphia, Pa.; J. F. Towers, Gary, Ind.; D. C. Ulray, De Pue, Ill.; Paul C. Van Zandt; Chas. E. Veat; F. K. Vial; C. H. Viol; A. von Babo; Max von Vopelins, Berlin, Germany; L. D. Vorce, Detroit, Mich.; H. J. Wagner; E. W. H. Waldo, Urbana, Ill.; Wm. H. Walker, Boston, Mass.; J. H. Warder; J. R. Warner; O. P. Watts, Madison, Wis.; F. V. Wedlock; Harold K. Weld; Fred B. Wheeler; C. S. Wickes, Merchantville; J. R. Wilson, Niagara Falls, N. Y.; Wm. L. Wilson; Edson R. Wolcott; Edward Wray; H. W. Young; W. V. Young; J. A. Yunck, South Orange, N. J.; E. Zaremba, Buffalo, N. Y.; J. G. Zimmerman, Milwaukee, Wis.

Notes on Chemistry and Metallurgy in Great Britain.

(From Our London Correspondent.)

The British Association.

At the recent meeting of the British Association at Sheffield Mr. J. E. STEAD, president of the chemical section, delivered a noteworthy address dealing mainly with the effect of sulphur and silicon on the state of the carbon in cast iron. He said there was experimental proof that when iron sulphide is present the carbide of iron crystallizes with a very small proportion of sulphur—not more than about one-thousandth part of the weight of the carbide. The exact nature of the iron-carbon-sulphur compound had not been ascertained, but it appeared almost certain that the sulphur rendered the carbide stable.

The evidence supported the view that during the solidification of iron-carbon hypo-eutectic alloys, after the crystallization of the primary austenite and also in the eutectic and hypo-eutectic alloys, the carbide is first formed and subsequently decomposes into graphite and austenite. It had been proved by chemical research that the freezing of the hypo-eutectic alloys low in silicon results in nearly all the silicon crystallizing out with the primary austenite, and it followed that on gradually increasing the carbon and thus reducing the quantity of primary austenite—silicon being constant—the austenite formed would be gradually enriched in silicon until saturated, when the excess of silicon united with part of the carbide forming carbo-silicide of iron. The same result followed on gradually increasing the silicon if other elements were constant. In alloys of eutectic proportions, and in hypo-eutectic alloys, as no primary austenite could form, the silicon crystallized primarily with the carbide.

In Cleveland pig containing about 1.5 per cent phosphorus a ternary iron-carbon-phosphorus eutectic took the place of the iron-iron-carbide eutectic. In white irons with 3 per cent carbon and less than 2 per cent silicon, after the formation of primary austenite carrying nearly all the silicon, the iron-iron-carbide did not then form, but plates of cementite, or iron carbide; the metal remaining fluid had now reached the composition of the tenary iron-carbon-phosphorus eutectic which solidified at 940° C. In Cleveland irons, which become gray on cooling and which do not contain any primary austenite, the same iron-carbon-phosphorus eutectic is the only one formed during cooling, and instead of an iron-carbon-silicon eutectic two distinct cementites crystallized—one a silico-carbide and the other carbide of iron with possibly a little silicide in solid solution.

Micro-examination of cold alloys to which a small proportion of sulphur had been added during fusion went to show that the carbo-silico-cementite crystallized primarily. The primary carbo-silicides were very unstable and were first to decompose, yielding graphite and silico-austenite. When no appreciable quantity of phosphorus was present, two cementites formed, one a silico-carbide and the other the carbide, and the two crystallized together as a eutectic mixture. The precise composition of these cementites had not at present been ascertained.

The grayness of commercial metal with high silicon and low sulphur resulted from the very unstable nature of the silico-carbides. When silicide of iron was heated at 1000° C. with pure white iron free from silicon, the carbide of the white iron was decomposed by the silicide. From this it would seem that when all the silicon present in hypo-eutectic alloys crystallized

out with the primary austenite then after the carbide had solidified the silicide diffused and caused separation of graphite from the carbide. Many gaps remained to be filled, and he trusted that others would follow up the research.

The Testing of Lathe Tool Steels.

In Section G, Professor Ripper read a paper in which he called attention to the want of uniformity of standard in testing lathe cutting tools. The methods most commonly employed were, firstly, finding how long the tool would run under certain constant conditions, and, secondly, the determination of the cutting speed which would wear out the edge in 20 minutes. He considered that the speed test afforded the more useful information, and suggested a "speed increment" test with which he had obtained trustworthy results with the smallest expenditure of time and material. The testing lathe should be capable of very fine adjustment of speed. The tool was started on a standard cut at a given surface speed—say, 30 ft. per minute—which was gradually and uniformly increased by 1 ft. per minute until the tool gave out. This corresponded to the way the load was increased in tensile tests. If the mean cutting speed throughout the test were multiplied by the area of cut, the product gave the cubic measure of material turned off and represented the efficiency of the tool.

The Testing of Files.

Professor Ripper also read a paper on this subject. He attributed certain irregularities in results obtained with the Herbert testing machine to the fact that the teeth of the file worked precisely in the same grooves on the test-bar stroke after stroke. This occasionally resulted in the teeth ceasing to cut and the face of the bar assuming a glazed appearance. He had devised a modification in which the ends of the file were connected to ball joints instead of being held rigidly. This ensures a variation of the path traversed by the file, and irregular results were to a great extent got rid of.

The Closing and Welding of Blowholes in Steel Ingots.

Professor H. M. Howe, of New York, stated in his paper that his investigations went to show that the gases in blowholes are reabsorbed and that the blowholes can be welded, but that reheating and rolling without delay at a high temperature should be carried out.

Professor Arnold was not able to endorse the author's conclusions as applying generally. There were blowholes free from oxidation which might be welded, and there were oxidized blowholes which could not.

Mr. W. H. Hatfield thought that the production of blowholes to exactly the extent necessary to remedy piping would be found very difficult. He deprecated the practice as tending to the production of unsound material.

Institute of Metals.

The autumn meeting of this Institute was held at Glasgow and was opened on Wednesday, Sept. 21, when Sir Gerard Muntz presided. Abstracts of the papers presented will be found on page 561 of our October issue and in the Synopsis of this issue. In the following an account of the discussions which followed is given.

Magnetic Alloys Formed from Non-Magnetic Materials.

The discussion of Mr. A. D. Ross's paper was opened by Dr. C. H. Carpenter, who remarked that all the alloys showing high magnetic properties contained manganese, which itself contained a certain amount of iron. The point arose as to the influence of the iron. He would assume that it was negligible, but the fact remained that all the magnetic alloys produced from non-magnetic materials contained some manganese, and he thought it would be premature to state that the influence of the iron was really negligible until similar results had been obtained from non-magnetic materials without manganese.

Prof. A. Gray remarked that manganese steel, which was generally regarded as non-magnetic, could be rendered strongly magnetic by adequate treatment. With regard to Dr. Carpenter's reference to the existence of iron in the manganese, it was a remarkable fact that a very small quantity of iron caused much greater magnetic effects than would be supposed, possibly through exerting an effect upon the structure of the metal and also upon its behavior under magnetic force.

Mr. F. Heap was of opinion that a metallographic research would throw more light upon the magnetic properties of these alloys than chemical examination would.

Mr. E. L. Rhead gave the results of investigations of the effect of the addition of various metals to manganese. Zinc and cadmium gave a considerable magnetic value, while the action of antimony and bismuth was much more marked. The results appeared to indicate that the probable effect of all these metals on manganese was to alter the structure of the material in such a way as to render it magnetic. Phosphorus and arsenic had a similar effect, but to a less extent.

Mr. J. S. G. Primrose mentioned that in the last report of the alloys research committee Dr. Rosenhein stated that alloys which were found to be magnetic could be grouped to a very great extent by their structural differences.

Heat Treatment of Brass.

Messrs. G. D. Bengough and O. F. Hudson presented a paper on "The Heat Treatment of Brass: Experiments on 70:30 Alloy." In the discussion Dr. C. H. Carpenter asked if the authors had found any second constituent in the burnt specimens? It was important to have that point cleared up. His own research indicated that in the 70:30 brass there was an inversion at about 460° C., and that change had also been detected pyrometrically.

Prof. T. Turner thought that Dr. Carpenter's explanation was correct. In the case of steel it was manifest that separation occurred under the conditions in question. However, the matter demanded careful investigation, for there was no doubt that questions connected with annealing presented the greatest mysteries of metallurgy at the present time.

Mr. F. Johnson said that manufacturers wanted a ready means of recognizing the results which might be expected from heat treatment at various temperatures, and the danger of over-annealing. Tests at high temperatures would be valuable.

Mr. H. H. Greer asked if the tubes which were burnt in annealing could be restored to their original condition? That was a point of importance for the manufacturers to study so that workmen's mistakes might be rectified.

Sir Gerard Muntz agreed that a change did occur in brass at about 450° C., and that might possibly explain some occurrences of which there had been no adequate explanation hitherto.

Mr. Hudson, in his reply, said that he had not observed any signs of the second constituent mentioned by Dr. Carpenter.

The Effect of Impurities on Copper.

Mr. F. Johnson read a paper on the effect of silver, bismuth and aluminium upon the mechanical properties of "tough pitch" copper containing arsenic, in concluding which he stated that the experiments had demonstrated that silver, bismuth and aluminium exercised very marked effects on the mechanical properties of arsenical copper and that those effects were more apparent in testing the hot-rolled than in the cold-worked and annealed material.

The discussion was opened by Prof. T. Turner, who said the paper illustrated the combination of practice with theory, concerning which a great deal had been said lately. The author's statements as to the effect of bismuth were important. The difference between the effects of 0.02 per cent and 0.05 per cent of bismuth was of great importance in the case of pure copper, but in tough pitch copper the amount might be increased to more than double the lower limit mentioned.

Dr. Carpenter considered that the theory put forward in the

paper was most probably correct. He had no doubt that the real explanation of some of the defects mentioned was the liberation of gases during solidification.

Mr. E. L. Rhead asked if antimony alone had such a deleterious effect on copper as was generally supposed, and whether the addition of arsenic modified the effect of antimony as well as of bismuth.

Sir Gerard Muntz said a great effect was produced on copper both by arsenic and oxygen, and variations in their amounts produced widely different results. It seemed to him that, before any definite conclusion could be arrived at either the arsenic or the oxygen must be kept constant in quantity. He advocated the use of metallic arsenic. He believed it was a fact that liberation of gases did occur at the moment of solidification. He did not see the necessity for casting copper under pressure, for no gases ought to be in the metal when it was finished.

The Efficiency of Scientific Research.

An article under this heading from an engineering correspondent in the *Times* of Sept. 14 called attention to the inefficiency and loss arising from the conditions under which research work is carried on in England at the present time, and from the reluctance to publish the results arrived at, especially when these results appear fruitless. The author says: "Men are afraid to mark the blind alleys of their searchings with a notice board. They pass on to other paths, and others time and again repeat the same futile cycle"; and he considers that the want of publication of inconclusive research is the chief cause of inefficiency. As a remedy for the large amount of duplication and the synchronous waste of effort arising from independent competent investigators working on the same subject, both in the experimental departments of large firms and in private laboratories, the author advocates the formation of a "Research Co-ordination Committee" to receive and publish reports, to allocate special spheres to the laboratories of universities and technical schools, and to disseminate information. Finally, the competition of endowed and subsidized laboratories with the work of the independent professional man is condemned as tending to extinguish the services rendered to scientific progress by the private consultant by forcing him to direct his energies into other channels.

Commenting on this article the *Times* expressed the opinion that all who have experience of the mental and physical labor and the material cost involved in scientific research will in some measure agree with the general principles advanced by the author of the article.

Market Prices.

SEPTEMBER, 1910.

Copper has had a downward tendency throughout the month, principally owing to the heavy stocks now carried constituting visible supplies. It opened at £55 15 0, falling slowly to the 21st, £54 16 0, recovering slightly on the 23d and closing at £57 16 0.

Tin has been very unsettled, rising sharply from the 2d to the 7th, when it had gone from £158 to £166. With fewer fluctuations it fell by the 14th to £156, thence recovering to £159 (27th), and closing at £158 10 0.

Lead, English, has been steady, with slight depression from 8th to 19th, closing at £13 2 6.

Iron, Hematite opening at 65/3, dipped sharply about 5th to 64/2, thence recovering, fell away on the 12th to 64/-, ultimately recovering to 65/-.

Scotch Pig has fallen off throughout the month, opening at 55/5½ and closing at 54/10½.

Cleveland Warrants have had a downward tendency, opening at 49/5 and sloping off gradually to 48/10. The industrial situation has affected iron prices.

	£	s.	d.
Alum, lump, loose, per ton	5	12	5
Antimony, black sulphide powder	24	0	0
Borax, British, refined crystal	16	0	0
Sulphate of ammonia, f.o.b. Liverpool, per ton	12	15	0
Sal-ammoniac, firsts, delivered U. K., per ton	42	0	0
Copper sulphate, per ton	18	0	0
Camphor, 1-oz. tablets		1	7
Caustic soda, ash, 48 per cent ordinary, per ton	5	10	0
Shellac, standard, T. N., orange spots, per cwt	4	1	0
Sulphur, recovered, per ton	5	0	0
Carbolic acid, liquid, 97/99 per cent, per gal			11½
Hydrochloric acid, per cwt		5	0
Creosote, ordinary good liquid, per gal			2½
Naphtha, solvent, 90 per cent at 160° C., per gal			10½
Petroleum, Russian, spot, per gal			5¾
Platinum, per ounce, nominal	6	17	6
Copper ore, 10 to 25 per cent, unit	8/10½	to	9 10½
Tin ore, 70 per cent, per ton	£95	to	97
Mica, small slab, in original cases, per lb.	6d.	to	1 0
Litharge, flake, per ton	15	0	0
Quicksilver, per bottle	8	7	6
Red lead, genuine, per ton	15	10	0
Bleaching powder, 35 per cent, per ton	4	5	0

India rubber, Para fine, opened at 7/11 and had not dropped much in price by the 21st, when it was 7/3½d. During the last week, however, this has again fallen off, closing at 6/6.

In the chemicals it will be noted that sulphate of ammonia has advanced 19/-, copper sulphate declined, shellac slightly so, naphtha 2½d, while platinum continues to appreciate.

Synopsis of Metallurgical and Chemical Literature.

Gold and Silver.

Filtration of Slime.—The filter press has long been the favorite means of handling slime in Australia, but the vacuum filter is becoming a serious rival. With a view to stimulating interest in the cheaper working of the filter press, M. W. VON BERNEWITZ has contributed to the current *Proceedings* of the Australasian Inst. of Min. Eng. some of the details of filter pressing slime at the Associated Northern Blocks. The average value of the ore is $6.50 per ton. It is dry crushed in Krupp mills, roasted in Merton furnaces, ground in pans with weak KCN solution, the slime thickened, agitated and pressed in Dehne presses. Press filling and washing are done with pumps. Each press holds 4.75 tons dry slime. The pressure used in filling is 60 lb. and the time required is 15 min. Washing is done at 74 tons pressure, forcing about four tons of water through in half an hour. Tests showed that at least 20 min. is required thoroughly to displace the cyanide, after which the residue has a value of 30c. per ton. Continued washing would reduce the value to 20c. per ton on slime from ore that had been well roasted. On ore that was high grade or that had been poorly roasted the difference due to long washing is greater; with a residue assaying $1.90 per ton the washed samples would be about 70c., and on a 95c. residue the washed sample would be worth about 48c. per ton. This shows the variations that can occur in washing. After washing the press is dried for 2 min. with air at 90 lb. pressure, using 2640 cu. ft. free air. The residue contains 22 per cent moisture. Two men dump 11 presses in 8 hours, being paid 64c. per press. The cycle of operations requires time in minutes as follows: Filling, 15; washing, 30; drying, 2; dumping, 30; total, 77 min. During 1909, 44,163 tons were treated, giving an average extraction of 93 per cent, and costing for agitating and cyaniding 31c., and for filter pressing 25c. per ton. Cost for disposal of residue, 10c. per ton.

The author calls attention to the need of some method of discharging the presses without opening them and mentions a style of press devised by one of the managers, in which pressure water can be directed against each cake, causing it to disintegrate and flow out through a launder formed in the press plates. From the brief description, the idea seems to follow that of the Merrill press which was developed at the Homestake, and has since been extensively used in this country and in Mexico.

Zinc Precipitation.—A series of experiments undertaken to ascertain just what occurs in each compartment of zinc boxes, with a view to possible economy in the use of zinc, is communicated to the July, 1910, *Journal* of the Chem. Met. & Min. Soc. of S. Africa, by F. D. PHILLIPS. The first experiment was made on strong extractor boxes of seven compartments. Precautions were taken in getting fair samples, 80 cc. of inflow and outflow solution being taken every 15 min. for a period of eight hours.

The following table shows the results of sampling a box two days after filling with fresh zinc, with precautions to prevent the formation of channels. Flow, 1.54 tons of solution per cu. ft. of zinc in 24 hours. Solution, 0.00209 per cent KCN; 0.005 per cent NaOH.

Comp. No.	Entering dwt. per ton.	Leaving dwt. per ton.	Extracting dwt. per ton.	Per cent extraction.	Per cent ext. of original value.
1	2.56	0.48	2.08	81.2	81.2
2	0.48	0.14	0.34	70.8	13.3
3	0.14	0.06	0.08	57.1	3.1
4	0.06	0.03	0.03	50.0	1.2
5	0.03	0.01	0.02	66.6	0.8
6	0.01	0.01	..	..	..
7	0.01	0.01	..	..	..

If the excellent work of the first compartment had continued through the other compartments the precipitation would have been complete in four compartments, whereas six were necessary. Why does precipitation fall off in the lower compartments? It appeared that the seventh compartment might be dispensed with, and this was done with successful results as shown by analyses made later.

Experiments with a lighter pack of zinc (330 lb. per compartment, or 18.3 lb. per cu. ft., as against 420 lb. per compartment, or 23.3 lb. per cu. ft.). Again the first compartment did all the work, giving an extraction of 71 per cent; the succeeding compartments preciptated the same amount each, but the assays showed that the lighter pack of zinc gave too high tailing value.

Similar experiments with slime extractor boxes showed that the first compartment did 90 per cent of the precipitation. The temperature of the slime solution is raised by waste steam heat, and this is believed to play an important part in the precipitation. In an effort to see whether it would pay to try recovering gold from tailing solutions, leaving the extractors with 0.02 dwt. gold, it was found that it would be profitable to put on an additional zinc compartment in each box.

Reinforced Concrete for Stamp Mills.—The heavy gravitation stamp has developed a number of new problems, among which is that of overcoming the effect of increased vibration in the foundations and frame. In the *South African Mining Journal* this phase of the subject, among others, is discussed by G. A. ROBERTSON. The first notable departure from the old timber king posts was at the City Deep mill, South Africa, where reinforced king posts were constructed. Prior to that, reinforced concrete had been used in the mortar box foundations. The success of the City Deep king posts leads the writer to suggest that a single monolithic structure comprising foundations, king posts and other frames of reinforced concrete should be successful. He points out that the lack, hitherto, of adequate means for testing the effect of vibration on different forms of reinforcement has now been supplied by the invention of machines for the purpose.

An interesting point is brought out in connection with the manufacture of reinforced concrete parts, viz., in the use of molds attached to a vibrating table which is operated when the molds are being filled. The vibration, combined with the sudden arresting motion, has the effect of producing a rapid solidification of the particles prior to the initial set of the cement. It is claimed that great density and homogeneity are thus obtained, and that cavities are entirely eliminated. This is in agreement with the observation that the vibration of a stamp mill produces a very dense concrete, when made during the operation of the mill. After the initial set of the cement the vibration has no effect on the strength of the material.

Removing Iron from Ore Pulp.—The presence of particles of iron in pulp is a disadvantage and any means of removing it easily is desirable. The *Transactions* of the South African Inst. Elec. Eng., for May, 1910, contains a description of a device for this purpose, by W. C. BROWN. It consists of a magnet with a circular pole, placed at an angle of 35 deg. under the classifier. As the pulp flows from the classifier it spreads over the pole of the magnet and any particles of iron are retained and brushed off later. The magnet revolves at the rate of 6 r.p.m. It has a cast-iron hollow core 6 in. in diameter and 10 in. long. The exciting coil consists of 5120 turns of No. 18 copper wire. The exciting current is 2½ amp, 110 volts, d.c. The pole plate is 20 in. in diameter and turned perfectly flat on top. Only the very finest iron is lost, this being due to the fact that the flow of pulp prevents the finest iron particles coming in contact with the magnet pole.

Slime Settler.—Description of a cheap and efficient settling tank is given by R. E. HUNTLEY, in the *Journal* of the Chamber of Mines of Western Australia. It consists of a galvanized iron tank, 20 ft. in diameter and 5 ft. deep. A false bottom of wooden sectors is arranged in the shape of an inverted cone, the apex of the cone being at the center of the tank and the base about 12 in. above the true bottom of the tank. The sectors are of 1 in. wood, ½ in. wide at one end and 5½ in. wide at the other, and are spaced ⅛ in. apart, so that slime may build up under them to form a solid conical bottom.

The overflow of the sand collecting vats is run to this settler, where it is received in a funnel placed above the middle of the tank. The funnel is 9 in. in diameter and extends 6 in. below the level of the pulp when the tank is full. The funnel is surrounded by a bucket 15 in. in diameter, the overflow of which is 3 in. below the surface. This arrangement gives quiet and even flow of slime into the tank. Clear water overflows the rim of the tank. When a tank is full, it is allowed to settle for 30 min., after which any clear water is siphoned off, and the sludge is pumped to the agitation vats by a 4-in. centrifugal pump. When the settler is being emptied a jet of weak cyanide solution is added to thin the sludge.

The overflow water contains 4 to 8 per cent solids, and the slime is thickened to 50 or 70 per cent solids. Time for emptying a vat containing 30 to 40 tons dry slime is 1½ hours. The agitation and aeration caused in the pumping tend to improve the extraction.

Lead and Copper.

Electrolytic Lead Refining.—In an extended description of the Trail (B. C.) lead smelter and refinery, in the Sept., 1910, issue of *Mines and Minerals*, J. M. TURNBULL gives details of the electrolytic lead refining. The tank room contains 240 tanks, 3 ft. x 8 ft. x 3½ ft., made of fir lined with asphalt, arranged in six double rows in a series of cascades. The electrolyte is kept in circulation by pumps. Each tank holds 20 anodes which are placed in position by a crane carrying a spacing frame. The anodes weigh 370 lb. each, and are cast with shoulder lugs to rest on the copper current bars. They are spaced 4½ in. apart.

The cathodes are sheets of pure lead made on a special machine invented in the refinery. The cathodes are 1/16 in. thick and are hung from copper bars between and outside of the anodes, there being 21 in each tank. The electrolyte is lead fluosilicate with free fluosilicic acid, averaging 12 per cent SiF_6 and 5 to 6 per cent lead. The tanks are operated with a current density of 16 amp per sq. ft. of cathode area; voltage, 0.32 volt per tank, which is reduced 0.02 volt by the contacts. The scrap from the anodes, after washing, amounts to 15 per cent, and is returned for remelting.

The electrolyte is made from fluorspar, silica and sulphuric acid, mixed in a cast-iron pan. The fumes are condensed in towers with water sprays, the acidified water being used over and over again until the strength is about 30 per cent fluosilicic acid.

It is proposed to add 180 tanks which will raise the plant capacity from 75 to 100 tons per day, and permit the lowering of the current density to 12 amp, which has been found more desirable.

An average analysis of 2000 tons of shipping lead is as follows: Arsenic and bismuth, nil; zinc, .0005 per cent; silver, .0013; copper, .00075; lead, 99.9938; iron, .00075; tin, .0001; antimony, .0028. The anode slime analyzes: silver, 35 per cent; antimony, 25 per cent; arsenic, 20 per cent; copper, 8 per cent; iron, bismuth, silica, tellurium and selenium in smaller quantities and traces.

The slime is refined, and dore metal running 960 to 975 fine is obtained for further refining.

Roasting and Sintering.—At the twenty-third annual meeting of the Montana Society of Engineers F. M. SMITH presented some data on the sintering of ores. After reviewing the history of roasting machines and the development of the various blast roasting processes, the speaker gave some data on the operation of the Dwight-Lloyd sintering furnace as used at the East Helena smelter.

The machine is a straight-line type, 28 ft. long over all, with an effective area of 30 in. wide by 150 in. long, or 31.25 sq. ft.

A 10-hp motor serves to operate the machine, the pug mill in which the charge is mixed and the platform elevator which raises the charge to the feed hopper. The sintering machine itself requires but 1 or 2 hp. The ore for roasting is crushed to ⅛ to ¼ in. diameter, mixed with about 4 per cent water in the pug mill and fed to the roaster. The product is a spongy material carrying about 4 per cent sulphur.

The machine is more flexible than the H-H process, and matte and flue dust are treated easily. Two characteristic mixtures used at East Helena are as follows: 68 per cent lead concentrate and slime; 12 per cent raw matter; 20 per cent miscellaneous sulphide ore and fine concentrates. The average analysis of these two mixtures is:

	SiO_2	Fe	Mn	S	Zn	Pb	Cu
No. 1	15.4	17.2	0.9	14.4	5.2	29.6	0.8
No. 2	11.5	16.9	1.0	13.0	2.7	30.0	1.0

These mixtures were sintered at the rate of 40 tons per 24 hours, and made excellent sintered products analyzing:

	SiO_2	Fe	Mn	S	Zn	Pb	Cu
No. 1	16.0	18.2	1.0	3.8	4.6	35.5	0.5
No. 2	13.6	18.9	1.0	4.0	6.3	35.0	0.8

In igniting the charge, gasoline is used under 80 lb. pressure. Two additional machines will be installed at this plant, each having a capacity of 100 tons per day. The present machine, with its 40-ton capacity, has about four times the capacity of one of the reverberatory furnaces with 840 sq. ft. of hearth area.

Impurities in Tough-Pitch Copper Containing Arsenic.—A paper presented by Mr. F. JOHNSON before the (British) Institute of Metals deals with "the effect of silver, bismuth and aluminium upon the mechanical properties of "tough-pitch" copper containing arsenic. The results of this investigation show that all three of the impurities—silver, bismuth and aluminium—have a very marked effect on the mechanical properties of arsenical copper, effects which are more apparent in the tests of the hot-rolled than in those of the cold-worked and annealed material.

The effect of silver in the proportions usually found in commercial "tough" arsenical copper may be considered as beneficial on the whole as regards mechanical properties and negligible as regards hot-working properties.

The effect of bismuth on the mechanical properties of "tough" arsenical copper which has been rolled is not serious up to 0.10 per cent; but no commercial arsenical copper could be regarded as fit for working at a red heat which contained so much bismuth. With 0.02 per cent, although the hot-working properties would be noticeably worse than if no bismuth were present, the copper would not be ruined. Any crude copper containing over 0.01 per cent bismuth should be regarded with suspicion, since the copper might contain traces of other impurities—*e.g.* nickel—which, while intensifying the injurious effect of bismuth, would hinder the corrective action of arsenic.

(The influence of bismuth on the mechanical properties of arsenical copper at high temperatures has not been investigated in this research.)

Arsenic and oxygen both aid in improving the mechanical properties of copper containing bismuth. In addition to the function exercised by cuprous oxide in guarding molten copper from the inroads of reducing-gases and their subsequent devastating influence, there may be ascribed thereto also the function of protecting the solid metal from the intercrystalline weakness engendered by metallic bismuth.

The effect of aluminium in arsenical copper is to destroy its hot-working properties and to impair its physical properties in the cast, and its mechanical properties in the rolled condition. (From advance sheets.)

Alloys.

Heat Treatment of Brass.—A paper read before the Institute of Metals by Messrs. G. D. BENGOUGH and O. F. HUDSON describes the results of an investigation in which the effects of heat treatment were studied on rolled and drawn 70:30 brass of varying size of section and of somewhat varying character, as made by different manufacturers. The experiments were also intended to throw some light on the question of "burning." For the purposes of the paper a sample of brass is considered to be burned when its ductility, as measured by the percentage elongation, has been lowered by heat treatment.

From the detailed study of the effects of various annealing temperatures upon the mechanical properties of cold-tested brass bars of commercial quality it appears that the best combination of strength and ductility is obtained for annealing temperatures between 600° C. and 700° C.

The true elastic limit was determined from one of the alloys used. This alloy did not appear to have a very well defined yield point, such as is exhibited, for example, in the case of mild steel.

The effects of varying the annealing period were also investigated. This factor has an even more important effect on the mechanical properties than the temperature factor. A temperature but a few degrees below the solidus, if only maintained for half an hour, will not seriously burn a bar of pure brass. A temperature nearly 100° C. lower will burn the brass if it is maintained for a sufficiently long time. Even small quantities of impurities have an important effect in increasing the tendency to burn. The atmosphere of the annealing furnace, whether oxidizing or reducing, does not appear to affect in any well-marked manner the properties of brass.

A few determinations of the loss of zinc by volatilization during the annealing process were made. This loss is appreciable, but is mainly a surface effect. The authors do not consider this to be the cause of burning.

Tests were made on the mechanical properties of brass wire at high temperatures. It was found that the maximum stress falls off continuously. The elongation and contraction of area, on the other hand, fall off to a very low value at temperatures between 300° C. and 400° C., after which a recovery of ductility occurs, and is practically maintained even at 590° C., the highest temperature employed. The suggestion is made that any handling of the material at a slightly higher temperature than usual may cause a permanent deterioration in its properties.

The authors studied the structure of annealed, over-annealed and burned brass by microphotographical methods and record new facts as to the crystal growth in brass at low annealing temperatures. (From advance sheets.)

Defects in Alloys.—A paper read before the Institute of Metals by Dr. CECIL H. DESCH gives a classification and discussion of "some common defects occurring in alloys." The intended composition is assumed to be a proper one for the purpose for which the alloy is to be used. The first class of defects includes those which are present in the original casting, and are classified as (1) sponginess, due to the enclosure of gas; (2) brittleness or weakness, due to the presence of (a) oxides or other drossy matter, (b) intercrystalline metal or eutectic alloy.

The author then discusses (3) defects, due to inequalities of composition. These may be due to (a) imperfect mixing of the ingredients; (b) separation by gravity during solidification; (c) segregation in the mould.

(5) Defects due to wrong thermal treatment may be caused by (a) quenching from a high temperature; (b) heating at too high a temperature or too long a time during annealing; (c) burning in the case of copper and zinc; (d) unequal thermal treatment of different parts of the same casting or forging.

The author then discusses (6) defects due to molecular change, other than that produced by mechanical stress; allotropic changes, tin plague, etc.

A great variety of defects are due to mechanical rather than to chemical causes. These include (7) shrinkage cracks; and (8) defects due to molecular change produced by mechanical deformation: (a) brittleness of cold-worked metals (1. season-cracks, 2, fire-cracks, 3 strain-disease or forcierkrankheit, (b) chilling cracks, (c) cracking during hot-working.

Finally (9) corrosion and (10) erosion are briefly discussed in the paper. (From advance sheets.)

Shrinkage of Antimony—Lead Alloys.—An Institute of Metals paper by Mr. DONALD EWEN and Prof. T. TURNER deals with the shrinkage of antimony-lead alloys and of aluminium-zinc alloys during and after solidification. The method of Ewen's experiments was the same as in M. T. Murray's former work on copper-zinc alloys, the changes of length of a cast bar being observed, by means of an extensometer, from the moment of solidification down to the ordinary temperature.

In the work of Murray on the copper-zinc series of alloys it was shown that where a continuous succession of solid solutions separate out, the extensometer curve closely follows the solidus. Ewen now shows that in the antimony-lead alloys, where no solid solutions exist, the extensometer curves give negative results, no single bar of the series having expanded more than the original antimony. The expansion due to the formation of the solid eutectic has, however, been noted. In the aluminium-zinc series, on the other hand, where solid solutions exist, Mr. Ewen finds that the expansion curve closely follows the liquidus curve from 0 to 50 per cent of aluminium, when allowance is made for the expansion noted at the eutectic point. (From advance sheets.)

Nitric Acid from Air.

The fixation of atmospheric nitrogen by means of electric discharges is the subject of five interesting papers published in the *Zeit. f. Electrochemie*, Oct. 1, and dealing with investigations carried out in Professor Haber's physico-chemical laboratory of the Institute of Technology of Karlsruhe.

F. HABER, A. KOENIG and E. PLATOU report on experiments made with a high-tension arc with artificial cooling. The first series of experiments was made with direct-current arcs, the object being the determination of a maximum concentration at reduced pressures. The arc was produced in a fused-quartz tube, water-cooled from the outside. The curve of concentrations produced shows a decided maximum (8.16 per cent NO) at an atmospheric pressure of 150 mm mercury (voltage 1400, current 0.27 amp). In a second series of experiments the authors determined the apparent phase-difference in an alternating-current arc and the yield obtained. With a power consumption of 0.7 kw with a concentration of 3.4 per cent NO 57 grams HNO_3 were obtained per kw-hour; this gives a yield of 500 kg HNO_3 per kw-year. In view of the high concentration this figure is fairly satisfactory, although it does not represent the maximum obtainable with cooled arcs.

Proof of this is given in a paper by W. HOLWECH and A. KOENIG, who obtained higher yields with a changed experimental arrangement using direct current. The arc was contained within very narrow cooled metallic tubes through which the air was pumped at high speed. Direct current of 1 amp at 6000 volts or 2 amp at 3000 volts was available. The best results were yields of 80 grams HNO_3 per kw-hour with a concentration of almost 2.5 per cent NO.

High-frequency alternating-current discharges were employed in experiments of F. HABER and E. PLATOU. The frequency does not have any great influence on the yield as long as care is taken to use a large amount of energy for the discharge and to extend the arc by blowing it out. If these precautions are not taken, yields are obtained which are below those obtained in commercial operation in European plants. It may be of interest to give these "commercial" yields. They are 50 grams to 75 grams HNO_3 with a 1.0 per cent to 2.5 per cent concentration of NO_2 and NO with preheated air. If the air is not preheated the "horn" discharge apparatus yields 50 grams HNO_3 per kw-hour.

While reduced atmospheric pressures have formerly been studied by Haber and his co-workers, F. HABER and W. HOLWECH have now also tried an increased pressure. But the results seem to show that no improvement of the yield can be obtained by an increase of pressure.

Finally A. WOLOKITIN reports at considerable length on the formation of nitrogen oxides in the hydrogen flame and the effect of pressure. The paper is chiefly of theoretical interest.

Recent Metallurgical and Chemical Patents

Copper.

The chemical treatment of copper ore containing gold and silver has always been open to the objection that the methods for profitably extracting the copper were not applicable to the precious metals, and vice versa. The object of a process recently patented by WILLIAM E. GREENAWALT, of Denver, Col., is to extract all these metals in one operation. The principles on which the process is based are these: Both sulphuric and hydrochloric acids act readily on copper in some of its combinations; chlorine acts readily on gold and silver; sulphur dioxide precipitates these metals from chloride solutions; sulphur dioxide combines with chlorine in the presence of water to form sulphuric and hydrochloric acids. The first step in the process is to form these two acids as indicated, and the next is to add an excess of chlorine to the acid solution. This solution will now dissolve gold, silver and copper in ores, the metallic chlorides formed holding the silver chloride in solution. When the solution is precipitated with sulphur dioxide, the acids are regenerated and the cupric chloride is reduced to cuprous chloride and precipitated. It can be withdrawn from the solution, melted at low red heat, cast into anodes and subjected to electrolysis. Several patents have been issued on various features of the process and the manner of carrying it out. (968,651-2. 968,845, Aug. 30, 1910.)

Gold and Silver.

An intermittent slime filter of novel construction has been patented in the United States by JOHN F. WEBB, of London, England. As illustrated in Fig. 1, which is a side elevation of the device, it consists of a rectangular filter medium which is alternately lowered, inverted, into the slime tank, and raised

to an inclined position for washing and discharge of the cake. The slime tank is represented at *f*, with the dotted lines showing the position of the filter when in the tank. The filter is shown raised for washing the cake prior to discharging. It consists of a metal box, one face of which is perforated and supports the filter cloth. The operating mechanism is a worm sector, *d*. Arms *b*, which are rigidly attached to the shaft of the sector, are pivotally attached to the filter. A connecting rod c^4, is also pivotally connected with the filter and a central support. In the revolution of the sector, the arms *b* support the filter, and with the aid of the connecting rod c^4 eventually guides the filter into its horizontal position in the slime tank. After the cake has formed the reverse of the operation lifts the filter into the position shown for washing and discharge of the cake. The weight of the filter is counterbalanced by the device shown, *c*, c^1, c^3. (968,720, Aug. 30, 1910.)

Sodium Amalgam.—The object of a recent invention by HERBERT P. EWELL, of Detroit, Mich., is to manufacture sodium amalgam and maintain it in a liquid state so that it can be used in the riffles or wells of gold amalgamating devices. In the manufacture of the amalgam, the inventor uses a receptacle for the mercury, over the surface of which he maintains a stratum of paraffine to exclude the air. The sodium, in a suitable container, is introduced into the mercury beneath the paraffine, and in order to prevent the formation of a hard amalgam the sodium is kept in constant agitation until dissolved. By the agitation the mercury is always in excess of the sodium at the point of solution, and the resulting amalgam is liquid and may be conveniently introduced into amalgamating machines. (969,853, Sept. 13, 1910.)

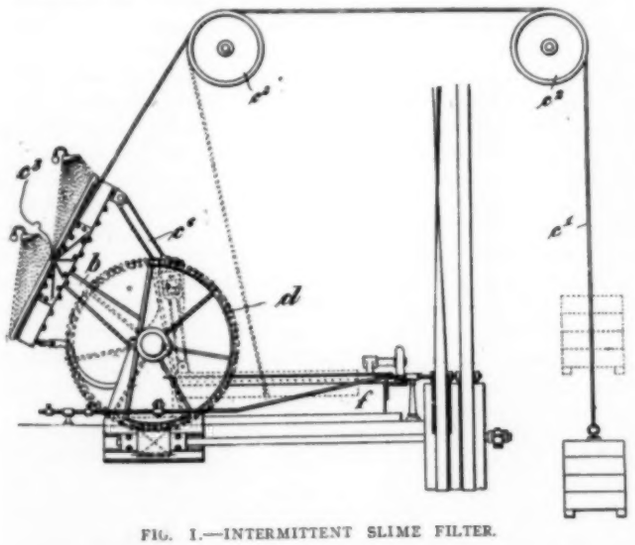

FIG. 1.—INTERMITTENT SLIME FILTER.

The solution of gold in cyanide solutions containing potassium cyanide and an oxidizing agent has been made the basis of some patents granted to JOHN C. CLANCY, of New York, and referred to in these columns in our issue of June, 1910, page 364. Recently Mr. Clancy has been granted an additional patent, the main point of which is contained in his single claim. "The method of treating pulverized ore containing gold, which consists in subjecting said ore to the action of a solution containing a soluble iodide and a substance capable of yielding nascent oxygen in the presence of said solution." It will be noted that the term gold is used instead of precious metals, as in former patents; also that no mention is made of a cyanide solution. The inventor claims that the process is applicable to unroasted ores, that it will take place in neutral, alkaline or acid solutions, and that the only addition of iodide necessary is to compensate for mechanical loss. The oxidizing agents used are sodium persulphate, ozone and nitrogen peroxide. The formula for one solution is 1 lb. of potassium iodide, 3 lb. of sodium persulphate and ½ lb. of lime or soda in one ton of water, using the solution in the proportion of two parts of solution to one of ore. (971,252, Sept. 27, 1910.)

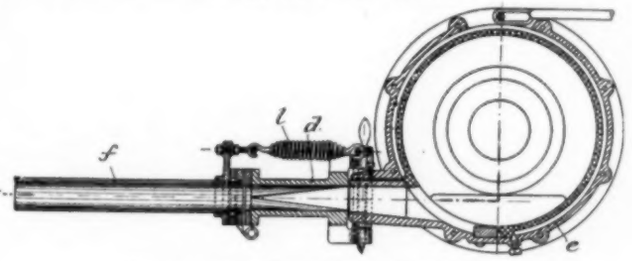

FIG. 2.—RETORT-CHARGING APPARATUS.

Zinc.

Furnace Charging Apparatus.—The convenient charging of retorts in zinc furnaces is accomplished by means of the apparatus illustrated in Fig. 2. It is the invention of EMILE DOR-DELATTRE, of Liége, Belgium. It comprises a propeller wheel with radial blades, revolving within a casing *e*. The charging tube *f* is jointed thereto, so as to yield or move angularly in the event that the charging apparatus fouls with any part of the furnace in being moved along the line of retorts. The tube *f* and the coupling sleeve *d* may be moved horizontally when the device is not in use. The outer end of the charging tube *f* may also be moved downward vertically on a horizontal hinge, and horizontally to either side on two vertical hinges. Normally, the spring *l* holds the tube in the position shown, but in case of the tube fouling with any other part of the furnace during use the tube will yield instead of breaking. (969,254, Sept. 6, 1910.)

Mercury.

Reduction Furnace.—A continuous process for reducing mercury ores is the basis of a patent granted to IRA HAGEMAN, of San Francisco, Cal. As illustrated in Fig. 3, the furnace is of the revolving type. It is oil-burning, as shown at 34 and 35, and has special devices to control the entrance and discharge of ore, as shown at the respective ends of the furnace. The furnace cylinder is represented by *a*, which revolves between fixed chambers *b* and *d* at the ends of the tube. The novel features lie in the means for continuously feeding and regulating the quantity of ore in the cylinder. The feed is by means of a

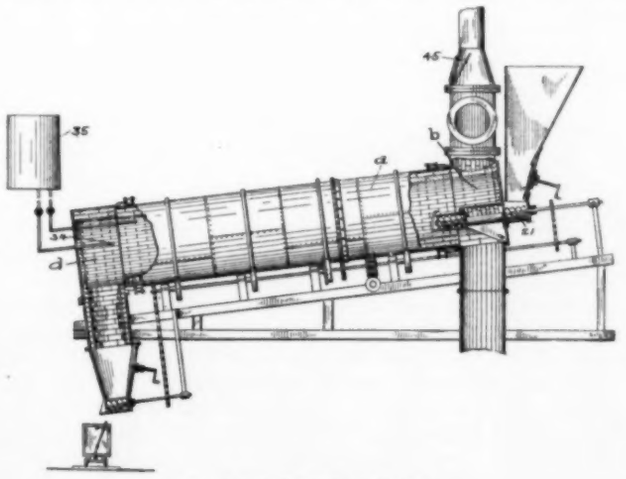

FIG. 3.—MERCURY FURNACE.

screw 21, operating in a cylinder connecting with the feed hopper. The end of the cylinder in which the screw operates is closed with a cap which is hinged so as to close the opening in the cylinder by gravity when the cap is not pushed away from its position by entering ore. The feed of ore becomes so packed in the cylinder that it also prevents the exit of fumes from the furnace. The discharge of the spent ore is controlled

by means of a hopper at the opposite end of the furnace. It will be noted that in each hopper, feed and discharge there is a controlling plate operated by a hand screw in each case, for the purpose of regulating the quantity of material delivered to the screws. Thus the quantity of ore in the furnace and the length of time it remains in the furnace may be controlled. Provision is made, as shown at 45, to connect the furnace with a stack until the proper running conditions have been obtained, after which the fumes from the ore can be directed through condensation chambers of such pattern that the fumes have to pass the entire length of the chambers before they can be discharged. There is also provided a suitable automatic water sealed safety valve on the condensing chambers. (970,705, Sept. 20, 1910.)

Roasters.

Wilfley Roasting Furnace.—The conditions necessary for successful roasting preliminary to magnetic separation are decidedly different to those obtaining in ordinary desulphurizing roasting. A patent recently was granted to Arthur R. Wilfley, of Denver, Col., on a roasting furnace designed for this special kind of work. It is illustrated in plan in Fig. 4. It is a rotary-hearth, stationary-rabble furnace, with firebox, feed hopper and a special device for removing the roasted ore from the hearth after it has traveled the full length of the hearth and has been subjected to the effect of the heat for a sufficient length of

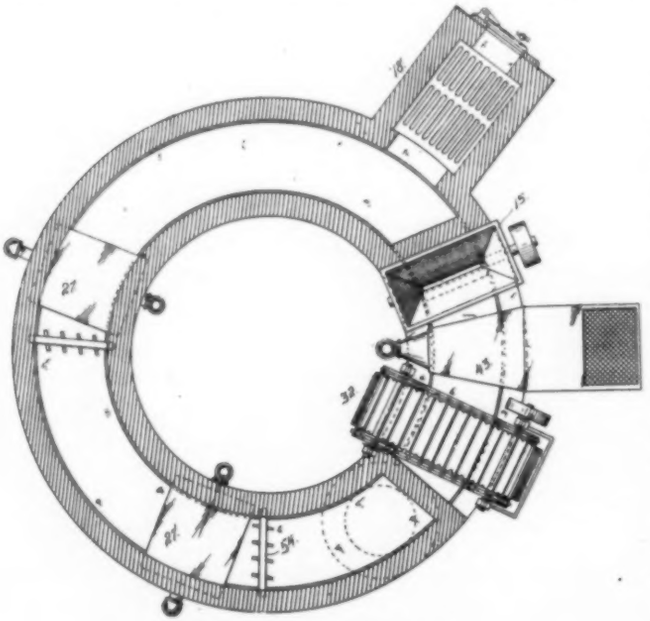

FIG. 4.—ROASTING FURNACE.

time. The firebox is located at 18, the feed hopper at 15, the endless brush, for removing the ore from the furnace, at 32, and the housing over the air blast, which is also used to remove ore from the hearth, at 43. Stationary rabbles are indicated at 54, and cooling jackets supported above the hearth at 27. In operation the ore is fed onto the hearth from the hopper and travels with the hearth past the firebox, passing later under the cooling jackets, in which water circulates constantly, and finally comes to the endless brush which removes it from the hearth. The air blast is used last to remove any particles, however small, which the brush has missed. The brush and air blast may be used separately or in combination. The rabbles may be dispensed with if the feed from the hopper is sufficiently thin to require no rabbling. The complete removal of the ore from the hearth at the end of the operation is highly essential to the subsequent operation of magnetic separation, as if the ore is allowed to remain in the furnace after the magnetic roast has been completed the subsequent heating will defeat the object of the process. (969,927, Sept. 13, 1910.)

Dust in Gas.

Settling Flue Dust.—Many schemes have been tried in the settling of dust from the flue gases of metallurgical furnaces, but usually these schemes have embodied the idea of causing the gas to flow in a tortuous path, both to reduce its speed and to provide baffles for retarding the solid particles which it is desired to settle. Mr. Henry Howard, of Boston, Mass., has been granted a patent on the idea of using superposed horizontal or inclined shelves in the flue, for the purpose of providing a means of settling the dust and retaining it. He has found that when the stream of dust-laden gas is confined in close proximity to a dust-retaining surface, such as metallic shelves separated by a vertical distance of 2 or 3 in., or less, a surprising result is secured. The chamber acquires practically the character of a filter, retaining even the finest particles of dust. The increased efficiency of the operation is believed to be due largely to the retardation, by the dust bed lying upon the shelves, of the lower portion of the shallow confined stream of dust-laden gas. It is observed in practice that the inlet end of the shelves quickly becomes obstructed and nearly closed by the accumulated deposit of dust, which slowly extends to the opposite end of the shelves. It is quite possible that those obstructions set up eddies in the current of gas, which aid in settling the dust particles. At suitable intervals the dust may be removed by some mechanical means. (970,053, Sept. 13, 1910.)

Electric and Electrolytic Furnaces.

Combined Resistance and Arc Furnace.—Mr. Johannes Härden, of the Gröndal-Kjellin Company, of London, England, patents a furnace in which resistance and arc heating are combined. Since the Gröndal-Kjellin Company is the owner of the induction furnace patents, it may be noted that in Mr. Härden's new combination furnace heating by induction is not employed. For resistance heating composite terminal plates are used as in the Roechling-Rodenhauser furnace, while arcs play on top of the bath and heat the refining slags to a high temperature. However, with a furnace of this combination the following difficulties are experienced, according to Mr. Härden: The metallic terminal plates are faced with conductors of the second class which become electric conductors when heated. When this takes place they become very hot and the metallic terminal plates are liable to be destroyed by melting. This would represent a serious source of danger. The above combination is, therefore, "not able to fulfil the requirements for dealing with large quantities of metal, since to avoid the destruction of the terminal plates the bulk of the electrical energy has to be conveyed to the charge by means of the electric arc or arcs, and when depriving the arc or arcs of electric energy the supply of energy to the whole furnace must be discontinued to prevent the terminal plates from being destroyed by overheating." Mr. Härden overcomes this difficulty in the following manner: In the composite terminal plate he provides a very steep temperature gradient between the face exposed to the charge of the furnace and the rear face of the plate, this rear face being kept comparatively cool. For this purpose the terminal plate is made of layers of material of increasing electric conductivity. At least three layers are employed. The metallic plate itself is artificially cooled. But between it and the highly refractory facing of magnesite, chromite or zirconite an intermediate layer of graphite or other carbonaceous material is packed. Such combination furnaces are claimed to be suitable for the treatment of "large quantities of steel, say, 30 tons or 50 tons." (967,909, Aug. 23, 1909.)

Metallic Sodium.—Mr. Paul Leon Hulin, of Grenoble, France (assigned to Société d'Electro-Chemie), remarks that in the manufacture of metallic sodium by electrolysis of fused caustic soda the quantity of sodium produced decreases somewhat after a short time. In such cases the electrolytic cell has been dismantled and refilled with fresh caustic soda. Mr. Hulin states that this is unnecessary and that it is suffi-

cient to take the cathode at intervals out of the bath, bring it into contact with the water or an aqueous solution, and then replace it in position. This remedy is stated to be effective. (971,198, Sept. 27, 1910.)

Electrolytic Processes.

Sodium Chloride Electrolysis.—A special feature of the familiar Townsend cell is the subject of a patent recently granted to Mr. CLINTON PAUL TOWNSEND (though first applied for on April 12, 1902). It will be sufficient to quote here two of the claims. The first claim relates to the "process of electrolyzing solutions, which consists in passing an electric current through the solution to an electrode and recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product." The ninth claim relates to the "process of electrolyzing solutions, which consists in passing an electric current through the solution and a diaphragm to an electrode, recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, and circulating said liquid in contact with said electrode by means of a gaseous product of the electrolysis." In the commercial Townsend cell the "immiscible liquid" is oil and the "gaseous product of electrolysis" used for circulation is hydrogen gas set free at the cathode. (972,947, Oct. 18, 1910.)

Barium and Strontium Hydroxides.—According to a process of Mr. ADOLF CLEMM, of Mannheim, Germany, barium chloride and strontium chloride are treated by electrolysis for the production of the hydroxides and chlorine. The electrolytic decomposition is carried to that point only where the chlorine solution is nearly saturated with the hydroxide (which is, for example, the case when electrolyzing barium chloride at a temperature of from 20° C. to 25° C. with an amount of from 35 grams to 40 grams of barium hydroxide within 1 liter). During electrolysis the cathode liquid is preferably heated to make use of the greated solubility of the hydroxide at higher temperatures (60 grams to 70 grams of barium hydroxide being carried in 1 liter at a temperature of from 50° C. to 60° C.). The solution thus obtained is then intensely cooled and the larger crystallizing part of the hydroxide in the solution is obtained in a pure state by centrifugal action and washing. The remaining liquid contains slight quantities of hydroxide which is turned back with the chloride into the process or which can be deposited in form of pure carbonate by means of carbonic acid. (973,171, Oct. 18, 1910.)

Magnetic Separation.

Detinning Tin Scrap.—An interesting application of magnetic separation is made in a detinning process of Mr. CHARLES J. REED, of Philadelphia, Pa. The tin scrap, mixed with finely divided magnetite, is charged into a rumble, in which it is subjected to heat and agitation until the tin softens and is scraped off from the pieces of sheet iron by the magnetite particles. The pieces of sheet iron are then separated from the magnetite and tin powder by means of a screen. Finally the magnetite is removed from the tin by magnetic separation. The process is also stated to be applicable to the treatment of galvanized-iron scrap, electroplated metal scrap, metal-carrying solder, etc. (971,405, Sept. 27, 1910.)

The **W. S. Tyler Co.**, of Cleveland, Ohio, has just issued a handsome catalog of 95 pages on "double crimped" wire cloth and mining screen. Several pages are devoted to information relative to the proper gaging, definition of mesh and the selection of suitable screen for various services and well executed full-page plates facing the text show various sizes, gages and types of wire cloth, together with suggestions as to its uses. The advantages of the "double crimp" in preserving accurate spacing and in presenting a weaving surface with crimps or arches of the same height, in both warp and shoot, give to this cloth an exceptionally long life.

Bakelite.

Through the recent incorporation of the General Bakelite Company the manufacture of bakelite has reached the large-scale commercial stage. The General Bakelite Company has been formed by a few men exceedingly well known as successful manufacturing chemists and some other well-known business men.

The General Bakelite Company controls all bakelite patents of Dr. Baekeland except the European patents, which are the property of the Bakelite Gesellschaft, 33 Lutzowstrasse, Berlin, Germany.

The following is a list of the United States bakelite patents: 939,966, 941,605, 942,699, 942,700, 942,808, 942,809, 942,852, 949,671, 954,666, 957,137. Other patents are pending.

The General Bakelite Company has been incorporated in New York State with a paid-up capital of $800,000. Dr. Leo H. Baekeland is president, Mr. Jacob Hasslacher is first vice-president and treasurer, Dr. Hans Foersterling second vice-president, Mr. Hugo Dubois secretary. Two other directors are Mr. Samuel T. Peters and Mr. R. H. Williams, both of New York City.

The manager of the General Bakelite Company is Mr. Herbert S. May, a graduate of the Massachusetts Institute of Technology.

A plant is now being equipped at Perth Amboy, N. J. Until it is finished goods are being turned out in Yonkers.

The company will undertake the systematic introduction of bakelite for different purposes and manufacture the raw materials therefor, supplying users of bakelite with different grades of preliminary products, leaving the mechanical side of the process to other manufacturers, who will produce the goods from them.

The offices of the company are at 100 William Street, New York City, where there is an interesting exhibition of samples of bakelite, illustrating the exceedingly manifold applications of this new substance.

These various applications of bakelite have been discussed at various times in this journal (see especially our Vol. VII, pages 111 and 276, and Vol. VIII, page 328). But the time seems now opportune to give a concise and full summary of the nature and properties of bakelite, indicating the many fields of its usefulness.

Bakelite is a new substance which, in its different forms, offers the advantages of hard rubber, Japanese lacquer, celluloid, and in many respects excel the properties of these products. Bakelite is not merely a mixture or so-called "compound" like so many rubber, shellac or other compositions, but a well-defined chemical substance of specific properties; it thus adds an important member to the industry of plastics.

In the synthesis of bakelite we have a more recent instance of a laboratory reaction, which seems to run along lines parallel to those of the delicate physiological changes which occur in plant life.

This synthesis has some relation to the subtle process which in the Japanese lacquer tree engenders the substance known under the name of Japanese lacquer. Up till now the latter has been a product of limited application and an article of luxury on account of its excessive price and scant supply. Henceforth a new material has become available which can be manufactured in practically limitless quantities and at a price which allows a wide range of uses.

The laboratory method is an improvement on nature's process, not only because the reaction is quicker and less expensive, but the resulting artificial product is decidedly more resisting to chemical and physical influences.

Dr. L. H. Baekeland, the inventor of this process, has a record of more than a quarter of a century of research in the field of pure and applied chemistry. To those outside of the chemical profession he is more particularly known through his inventive and industrial achievement in the industry of so-called

gaslight photographic papers, of which velox is the best known representative.

He presented the first general account of the synthesis of bakelite and its industrial application before the New York Section of the American Chemical Society on Feb. 7. 1909, several years after he had started his investigations on this subject and after he had obtained due protection by filing the necessary patents here and abroad. This paper was printed in our Vol. VII, page 111.

The word bakelite was selected as a simpler trade name for the longer and less expedient chemical name oxybenzylmethylenglycolanhydride.

For the layman it is somewhat startling that in the formation of bakelite two strong smelling liquid substances (carbolic acid and formaldehyde) should, under certain well defined conditions, react chemically upon each other and solidify to a transparent amberlike solid substance entirely devoid of odor and taste.

The various uses of bakelite will be better understood if we mention summarily some of its properties.

The final product, bakelite C, is infusible and can resist temperatures of 572° F. (300° C.) or over. It is insoluble in all solvents and can withstand strong chemicals, oil, hot water, steam, etc. All this in conjunction with its dielectric properties makes it an excellent electrical insulator.

Bakelite can be compounded with various filling materials and shaped or molded with great accuracy to articles of unusual strength. Or it can be sawed, turned and polished.

It can be used to impregnate wood and other porous bodies, rendering them harder and more resisting to chemical and physical influences. Or it can be obtained as transparent as glass, or colored to suit special requirements.

It can be purchased at a reasonable price, the latter varying with its different qualities.

Although bakelite is stronger and harder than celluloid or hard rubber, it lacks the unusual flexibility of both these plastics. Rods or plates made of it, or its compositions, are somewhat flexible, but considerably less so than celluloid or hard rubber.

On the other hand, it withstands incomparably better high temperatures and in general all chemicals and physical influences, and has the further advantage of not being attacked by solvents or by most chemicals. It does not emanate sulphur vapors like hard rubber, nor nitrous products like celluloid, which have a very disturbing influence in some electrical applications. If heated in a flame it does not suddenly catch fire like celluloid nor melt like rubber; it simply chars, then burns with difficulty.

During the act of hardening, which engenders the final product, there is a shrinkage of about 2 per cent in diameter, or in length. This shrinkage can be lessened by the judicious incorporation of filling materials and if the latter be used in large amounts the decrease in volume can be reduced to such a point as to make it hardly perceptible. Its specific gravity is about 1.25.

The bakelite process involves the utilization of three distinct and well defined varieties of bakelite, designated bakelite A, bakelite B and bakelite C. Bakelite C is the final product, whereas A and B are the transition products which enable us to mold or otherwise apply the material before its final hard condition.

Bakelite A is the initial raw material and exists in liquid, pasty or solid condition. Every variety of A, if heated at a sufficiently high temperature, changes into B, then into C. All varieties of A, whether they be liquid, pasty or solid, are still soluble in alcohol or acetone or in caustic soda, and behave as true resins. *Solid A* is characterized by the fact that it is solid at ordinary temperatures, but melts if moderate heat is applied, while stronger application of heat makes it infusible and insoluble by transforming it into B or C.

Bakelite B is an intermediate solid product. It is neither so hard nor so strong as C and may be easily mistaken for solid A, but it is different from the latter on account of its insolubility. Furthermore, it is infusible, although the application of heat may temporarily soften it, without, however, bringing it into fusion. Solvents do not dissolve it, but some of them, like phenol or acetone, may soften it or swell it without bringing it into solution. B is specially characterized by the fact that, although it is infusible, it will soften under the action of heat and then will mold and weld together if pressed in a hot hydraulic press. The latter fact differentiates it clearly from C.

Bakelite C is the final product, resulting from the application of heat on A or B, and may be considered as a chemical polymer of B resulting from a multiple molecular grouping. It is no longer a resin, because it lacks all the chemical characteristics of a resin, although physically it may resemble amber. In pure form, and if made from the first member of the phenol group, its chemical formula is represented by $C_{36}H_{30}O_7$. It has maximum strength and maximum resistance to chemical influences.

Although the preparatory work connected with the industrial side of the process has been going on with strenuous application since 1907, it was thought advisable not to jeopardize everything by a too hasty, broadcast introduction before each industrial use had been studied for a sufficiently long time on a practical commercial scale.

For this reason bakelite has been used during the last two years "on the quiet," especially for electrical purposes, while undergoing the test of time and the critical observations of every-day practice under the eyes of specialists. This work has been conducted on a sufficiently large scale to remove all doubts as to the practical side of the question. It can thus be stated without hesitation that bakelite is no longer a laboratory experiment but a product well tried in several industries.

Special conditions may, from time to time, arise which will necessitate changes in the directions to be followed for the manufacture of bakelite products. Further, the field for the application of bakelite being so unusually large, new uses sanctioned by preliminary trial will come up from time to time. All such special fields and new fields will be worked out by the General Bakelite Company, and its policy will be to abstain from recommending any applications of bakelite until first sufficient data have been gathered to make sure of its practical merits.

Bakelite electrical insulators as well as bakelite pump valves, valve disks and other molded goods are now obtainable from several of the licensees of the company.

Automatic Annealing Furnace.

Automatic operation has been extended as far as practically possible in a new annealing furnace placed on the market by the Hawley Down Draft Furnace Company, of Chicago. It was invented by its general manager, Mr. Cliff Bleyer.

All the operations are performed by electric motors, controlled by an electric clock. The furnace (Fig. 1) is heated by oil burners and after the proper temperature has been attained in starting the furnace no further attention is required except an inspection every eight or ten hours, which is sufficient to keep the temperature of the furnace uniform. But an electric pyrometer permits to read the furnace temperature at any time.

This furnace is especially suitable for light castings, like cartridge shells, and for any kind of small gray iron or metal castings requiring a short annealing period. The charge is automatically weighed into the furnace, kept there for the length of time required by the work and controlled by the clock, then automatically discharged by tilting the furnace (Fig. 2); the truck which carries the annealed castings away operates automatically on a track, discharging its load at any point for which the mechanism is adjusted; the truck then returns to its station under the furnace.

The furnace is heated by two fuel oil burners of the type used in metal melting furnaces. The flames enter the bottom of the furnace, but are deflected toward the outlet (Fig. 1) so as not to make contact with the castings.

The electric clock controls the motors in such a way that at the specified moment either the minute or the hour hand makes contact with one of a set of plugs placed in the face of the clock and thus closes an electric circuit which operates the motor.

The furnace is charged from an overhead hopper of sufficient capacity to keep the plant in continuous operation. From the hopper the castings pass to an automatic scale which can be adjusted to weigh charges in any amount from 50 lb. to 500 lb. When a lot of castings has been discharged from the furnace usually a short interval is allowed to let the furnace recover any lost heat. Then a new charge is introduced into the furnace, the castings sliding from the scales into the furnace.

To control this sliding movement the wedge-shaped brick projecting upward from the bottom of the furnace at the center is of importance. As seen in Fig. 1 the face of this brick is curved, so as to act as a slide and permit the castings

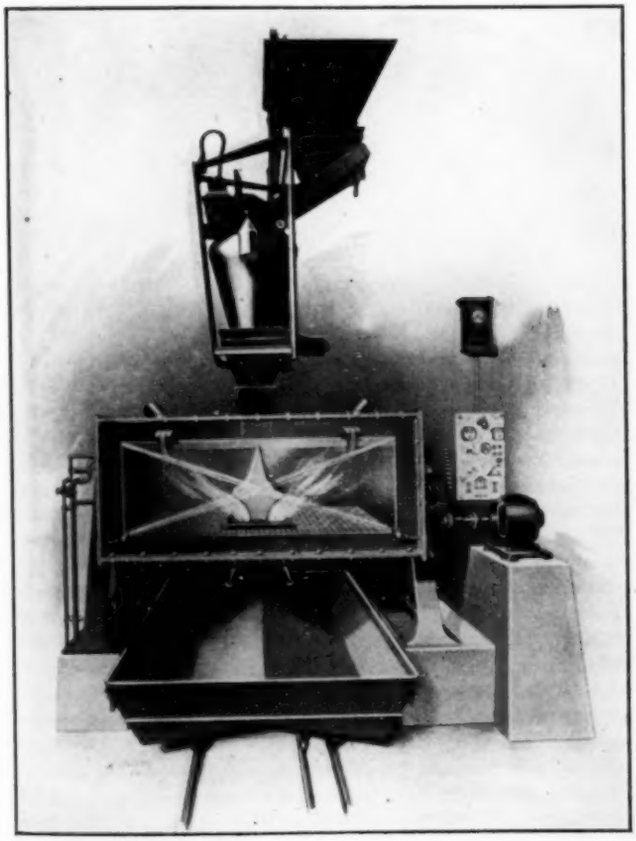

FIG. 1.—GENERAL VIEW OF AUTOMATIC ANNEALING FURNACE.

to be deposited in the furnace without any sudden jar. This brick also serves as a flame deflector to protect the castings from direct contact with the flame.

The oblong shell of the furnace is formed by six heavy cast-iron plates bolted together. It is lined with from 4 in. to 8 in. of firebrick, and between the iron shell and the firebrick lining an interlining of asbestos varying in thickness from ½ in. to ⅞ in. is interposed for heat insulation.

The tilting of the furnace is accomplished by gears operated by two electric motors, both of which are controlled by the electric clock. One of the motors controls the discharge of the castings from the furnace and its return to the position in which it receives a new load, through an angle of 90 deg. The other motor tilts the furnace forward and backward through an arc of 45 deg. and turns the castings. The object is to change at regular intervals the position of the castings in the furnace so that they are subjected to a uniform heat treatment on all sides. For instance, the castings may be turned around once in the middle of the heat.

Every charge weighed into the furnace is recorded and the amount of material that is passed through the furnace can be seen at any time, so that a check is obtained on the foundry and finishing departments and also an exact record of the amount of material handled.

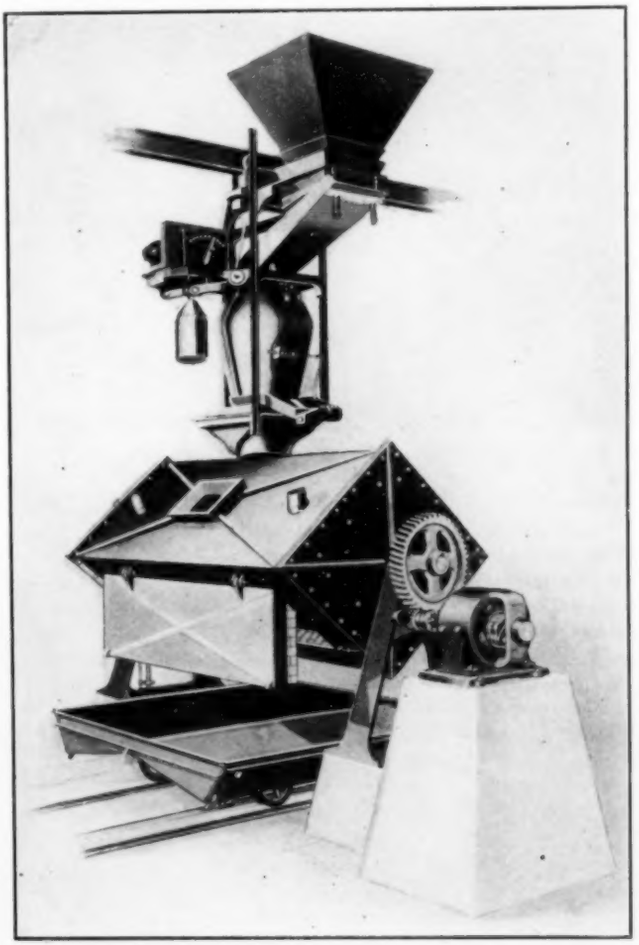

FIG. 2.—DISCHARGE OF AUTOMATIC ANNEALING FURNACE.

Volatile Matter of Coal.

"The Volatile Matter of Coal" is the title of the first bulletin just issued by the new Federal Bureau of Mines. The authors, Horace C. Porter and F. K. Ovitz, conducted their investigations at the Pittsburgh station while it was under the Technologic Branch of the Geological Survey, the work being a continuation of the fuel investigations begun several years ago at the Louisiana Purchase Exposition, St. Louis, Mo.

The results obtained at that plant showed that the work of determining the fuel values of the coals and lignites in the United States with a view to increasing efficiency in their utilization would be incomplete if it did not include systematic physical and chemical researches into the processes of combustion. Hence in their later investigations the authors carried on such researches, concentrating attention on those lines of inquiry which promised results of greatest economic importance. This bulletin is therefore a report on an investigation of the volatile matter in several typical coals—its composition and amount at different temperatures of volatilization.

Quoted directly the authors say: "The investigation has already shown that the volatile content of different coals differs greatly in character. The volatile matter of the younger coals found in the West includes a large proportion of carbon dioxide, carbon monoxide and water, and a correspondingly small proportion of hydrocarbons and tarry vapors. The older bituminous coals of the Appalachian region yield volatile matter containing large amounts of tarry vapors and hydrocarbons,

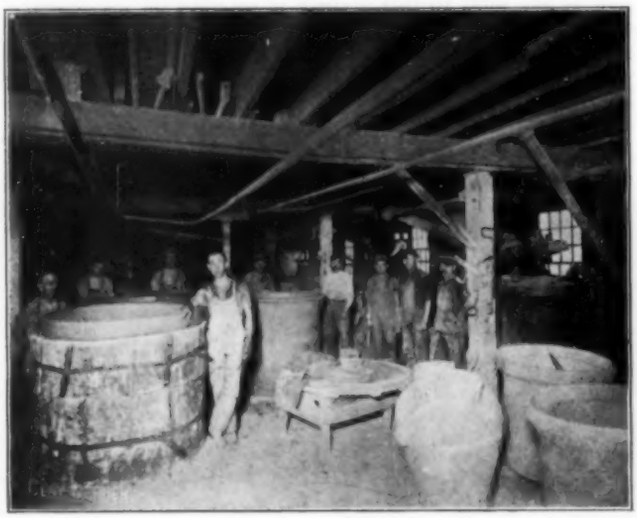

FIG. 1.—LARGE STORAGE TANKS, TOWER PIPE AND RECEIVERS.

difficult to burn completely without considerable excess of air and a high temperature. Coal of the Western type, moreover, gives up its volatile matter more easily at moderate and low temperatures than that of the other type. The volatile matter produced at medium and low temperatures is rich in higher hydrocarbons of the methane type, such as ethane and propane, which contain a larger portion of carbon than is present in methane.

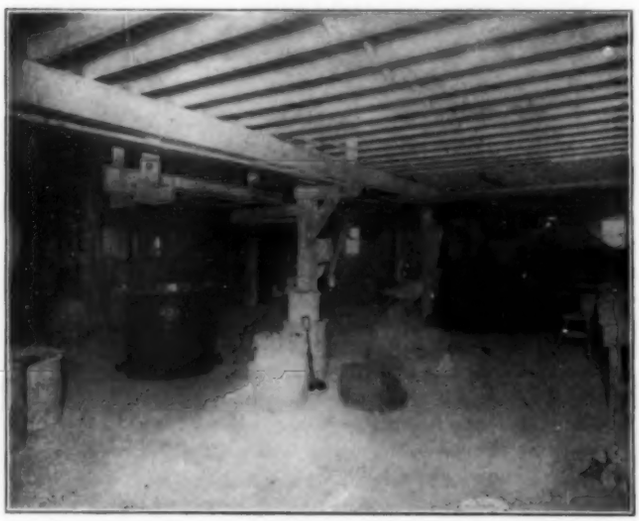

FIG. 2.—MILL ROOM, WITH 200-GAL. JAR.

"These facts help to explain the difficulty of burning Pittsburgh coal, for example, without smoke, the low efficiency usually obtained in burning high-volatile Western coals, the advantage of a pre-heated auxiliary air supply introduced over a fuel bed, and the advantage of a furnace and boiler setting adapted to the type of fuel used. They bear directly also on the question of steaming 'capacity' of coal for locomotives, the designing and operation of gas producers for high-volatile fuels and also on the operation of coke ovens and of gas retorts.

"The results show further that certain bituminous coals of the interior and Rocky Mountain provinces give promise of good yields of by-products of coking, notably ammonia and high-candle-power gas, comparing favorably in these respects with the high grade coking coals of the Eastern province.

"They show also that inert, noncombustible material is present in the volatile products of different kinds of coal to an extent ranging from 1 to 15 per cent of the coal."

The bulletin will be of interest to fuel engineers, designers and builders of gas producers, gas and coke manufacturers, superintendents of power plants, railway master mechanics and those engaged in the suppression of smoke. The bulletin may be obtained by applying to the director of the Bureau of Mines, Washington, D. C.

FIG. 3.—DRYING FLOOR.

Acid-Proof Stoneware Tanks.

The making of acid-proof stoneware tanks, particularly in sizes larger than commonly used, has always been rather difficult as the piece is liable to crack or warp while drying and burning.

The shapes and capacities required are so varied that it is usually impracticable to attempt to carry "stock sizes," as a user would then have to take the nearest size to what he wants and make it do or would have to pay an additional charge for the variations. Most stoneware companies are prepared to furnish without delay special pieces according to blue-prints submitted. As most tanks and special pieces have to be made by hand, anyway, the consumer may as well have exactly what he needs, according to his specifications.

Each manufacturer has mixtures and methods which he does not care to divulge, but the process, in general, consists in tempering different clays, adjusting the proportions to give the body strength and ability to resist temperature changes as well as the action of acids. In the composition for chemical purposes almost pure silica plays an important rôle. The piece is shaped and allowed to dry for a few days, then the acid-proof glaze is applied in spray or soft-paste form and further dried. It is then baked for several days at about 2500° Fahr. to insure a uniform vitreous body, which, even without the enamel, is a good resistor of acids. The kiln is then allowed to cool slowly and uniformly to insure proper annealing.

The adjoining illustrations give views of several parts of the plant of Mr. A. J. Weeks, of Akron, Ohio. Fig. 1 shows the manufacture of large storage tanks, tower pipe and receivers. Fig. 2 is the millroom, showing machines and a 200-gal. jar. Fig. 3 shows a drying floor of the works, and Fig. 4 the drying of chemical rings with partitions for chemical towers.

Among the tanks recently made by Mr. Weeks are several for the American Steel & Wire Company. They are intended for pickling wire in sulphuric acid during the galvanizing process, the strands of wire running under large depressor spools which rest on hubs fastened to the tanks. The tank dimensions are 4 ft. by 5 ft. by 14 in. Several of these tanks, as well as flux jars from 50 gal. to 500 gal. capacity and flux pitchers, have been furnished by Mr. Weeks to the steel industry.

FIG. 4.—DRYING CHEMICAL RINGS.

Metallurgy in the Dutch East Indies.

Tin.

The government tin mines and smelters at the Island Banka produced during the year 1908-1909 (from Feb. 2, 1908, to Jan. 21, 1909, e. g., during 356 days) 204,190.70 pikols tin, against 191,930.22 pikols during 1907-1908 (1 pikol = 65 kg = 143 lb.). The laboring force consisted of 20,126 men (all Chinamen), against 19,106 in 1907-1908. The total production cost of 1 pikol tin, including freight to Tandjong Priok during the year 1908-1909, was Fl. 47.34. The average price made was Fl. 96.10. In the years 1907-1908 and 1906-1907 these figures were Fl. 44.61, Fl. 123.94, Fl. 35.67 and Fl. 128.26, respectively; 29,509.92 pikols impure tin had to be refined by liquating them. The cost of refining, including the smelting of the liquation residue and liquating the resulting tin, was Fl. 0.90 per pikol.

The Billiton Maatschappy, which operates on the Island Billiton, produced during the year 1908-1909 (ending April 1, 1909) 66,680 pikols tin, 29,900 of which were shipped to Singapore in the form of ore to be smelted there. The laboring force consisted of 13,608 men, e. g., the production per man was 4.9 pikol; 36,383.36 pikol were sold at Batavia at an average price of Fl. 93.29 per pikol. The price made at Singapore corresponded to Fl. 93.90 per Java pikol. The net profit amounted to Fl. 2,299,958.52, of which 5/8, e. g., Fl. 1,437,474.07, goes to the Dutch government. 144.79 pikols mixed wolframite tin ore concentrates were produced by concentrating ores mined the preceding year. This company contemplates at the present time to break with their old smelting method in van Vlaanderen shaft furnaces (these furnaces are also used at Banka) and to erect modern gas-fired reverberatory furnaces of the Schmidt & Desgraz type, which met with considerable success in European tin smelting.

The Singkep Tin Maatschappy operates on the Island Singkep (Lingga Archipel; Riouw). The production during the year from July 1, 1907, to June 30, 1908, was 6,441.18 pikols tin and 200 pikols wolframite. The ore is all shipped to Singapore and smelted there. The same was sold for $66.99 per Straits pikol, e. g., Fl. 95.78 per Java pikol of 65 kg against 134.13, Fl. last year's price. The net profit of the company was Fl. 65,855.05 against Fl. 199,835.305 last year's net profit. This company had to stop working its sea concession by Tiking as it did not pay the expense. A dredge is ordered which will be able to raise the ore from 40 ft. under the sea level.

Gold and Silver.

Lebong Donok Concession (Benkoelen, Sumatra) of the "Mynbouw Maatschappy Redjang, Lebong) during the year 1908 1058 m of tunnel were driven, increasing the available amount of ore to 319,249 metric tons at Dec. 31, 1908, with an assay value of 19.6 dwts. to the ton. The third level was opened up over the entire length and the South shaft had been sunk to 5 m below the third level as preliminary work for a fourth level. The number of stamps was increased to 70 and the number of rotating comminutating cylinders to 6, four of which were in operation; 12.82 per cent of the gold and 1.33 per cent of the silver contained in the ore was extracted by amalgamation and 84.99 per cent of the gold and 77.09 per cent of the silver contained in the sand were extracted by cyaniding the sand (40,454 tons of sand were treated). The slime plant treated 46,287 tons slime, 91.27 per cent of the gold and 76.68 per cent of the silver contained in the slimes were extracted by cyaniding.

Altogether 89,773 tons of ore containing 20.69 dwts. gold and 139.25 dwts. silver were treated and 82,873.4 oz. gold and 471,743.1 oz. silver obtained, representing a value of Fl. 4,761,-000. The net profit over 1908 was Fl. 2,940,675.

Lebong Soelit Concession (Benkoelen, Sumatra) of the Mynbouw Maatschappy Ketahoen: 1790 m of tunnel were driven during 1908, increasing the available ore to 162,600 tons, with an average of 12.02 dwts. gold to the ton. The number of stamps was increased from 30 to 40. The stamp mill treated 33,029 tons of ore, the ball mill 6672 tons. The extraction by amalgamation was in the stamp mill 54 per cent and in the ball mill 20.4 per cent of the gold contained in the ore; 24,965 tons of sand were treated by cyaniding. The average extraction was 82.8 per cent of the gold and 59.3 per cent of the silver contained in the sand; 12,791 tons of slimes were treated by the cyanide process and an extraction of 76.9 per cent of the gold and 39.8 per cent of the silver contained in the slimes was obtained.

The total production was 26,177.7 oz. gold and 45,168.5 oz. silver, representing a value of Fl. 1,377,823. The total cost of production was Fl. 20.81 per ton of ore and the company's profit Fl. 541.500.

Concession "Totok" (Res. Menado) of the Mynbouw Maatschappy "Totok."—This company proceeded in 1908 working the deposits Haies, Liang and Tehosi by hydraulic mining. The coarse material goes to the stamp mills (two of 20 stamps each, which are direct-coupled with Pelton wheels); the fine material to concentration and amalgamation tables. The tailings of the stamp mill go to the dump; 70,334 tons of ore were treated and 318.8 kg of gold and 123 kg of silver, representing a value of Fl. 536,973, were extracted.

Concession "Paleleh" (Res. Menado) of the Mynbouw Maatschappy Paleleh: 2880 m. of tunnel and shaft were driven during 1908, increasing the amount of available ore to 87,000 tons. Thirty-six thousand nine hundred and eighty-five tons of ore, containing 10.07 grams of gold to the ton were treated and 260.158 grams of gold and 71.283 grams of silver were extracted by amalgamation, e.g., a gold extraction of 70.5 per cent. Thirty stamps were in continuous operation and 20 new ones were put up.

The Consolidated Mining & Smelting Company, operating copper and lead smelters at Trail, B. C., has, during the past year, erected an ore testing plant to determine the methods of economically treating ores, and to devise improvements on the present methods of concentrating ores from its mines.

NOTES

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in July, 1910, was 72. There were milled 1,865,318 tons of ore; 9826 stamps were in operation with an average duty of 7.07 tons per 24 hours; 179 tube mills were at work. Comparison with last year shows an increase in the tonnage milled, number of stamps and number of tube mills in operation. The yield for the month was 638,714 fine ounces, being the largest yield for the year 1910, and larger than for 1909 up to the same month.

The Colorado Iron Works Company, Denver, has sent us pamphlets Nos. 24, 26 and 27, describing, respectively, the Akins classifier, the Rothwell continuous thickener and filter, and the Akins-Rothwell agitating tank. These are devices which will interest those engaged in the cyanide industry.

The **International Acheson Graphite Company** has opened a Southern branch in Atlanta, Ga. The company is greatly pleased with the appreciation shown for its lubricants—Gredag, Oildag, Aquadag and its pure powered graphite—by Southern industries.

The **Wood Turpentine Association** held a meeting at Jacksonville, Fla., on Sept. 24, which was attended by representatives of a large number of plants engaged in the manufacture of high-grade wood spirits of turpentine and pine oil. The main object of the association at the present time is to improve the quality of their products and to establish uniform standards to which all the members of the association will bring their products before placing them on the market. The officers of the association are: Dr. J. E. Teeple, of New York, president, and Mr. A. J. Grant, of Orlando, Fla., secretary.

The **Noble Electric Steel Company** is reported to have plans prepared for the installation of five additional furnaces at its large smelter at Heroult, at a cost of about $300,000. The company is developing several chrome mines near its smelter. Since the demonstration in July of the electric process the furnace has been closed down owing to the Northern California Power Company being unable to supply electricity during the dry season to operate the plant.

The **Moler brick,** which has been mentioned repeatedly in this journal as a new refractory for certain metallurgical purposes (see especially vol. VII, p. 474), is being made by the Frederickshoims Tegl & Kalkvaerker in various shapes. This brick is used largely for partition walls in steel buildings because of its lightness. Messrs. Carl J. Michaelsen & Co., Ameliegade 26, Copenhagen, Denmark, are the sole exporters.

The **American Association of Commerce and Trade,** Berlin, Germany, is an American Chamber of Commerce, founded seven years ago by Americans and is run by Americans on American lines for the purpose of promoting American trade with Germany and German trade with the United States. It was organized especially for assisting American business firms to start branches in Germany. The organization with offices at the Equitable Building, 59-60 Friedrichstrasse, Berlin, has the largest and most complete American reading-room in Germany, where thirty daily American papers and 150 trade publications are available, besides all United States Government reports and statistics, all the directories of the leading American and German cities, all the principal telegraph codes. This reading-room is open to American business men and travelers visiting Berlin.

Remarkable Properties of Cobalt-Chromium Alloys.—While nickel-chromium alloys have come into extended use in recent years in form of a non-oxidizing resistance wire for electric furnace and electric heating purposes, considerable attention has recently been drawn to the sister alloy cobalt-chromium through the work of Mr. Elwood Haynes, of the Haynes Automobile Company, of Kokomo, Ind. An alloy of 75 per cent cobalt and 25 chromium, properly prepared, is very tough and malleable and can be hammered out into exceedingly thin sheets at a bright red heat without cracking. Blades of this alloy have been used with good success for razors. Tensile tests have given an elastic limit of 79,000 lb., a tensile strength of 96,000 lb. and an elongation of 3 per cent. By charges of the proportions and addition of other elements alloys can be produced which are practically not attacked at all by nitric acid and which are sufficiently soft and malleable to be worked cold. This would seem to open a field for the use of this alloy in vessels and appliances for chemical work if the cost is not too high. The most useful property of the alloy is its extreme resistance to corrosion, in which respect it is said to be equal to gold and platinum. Sulphuric acid and hydrochloric acid attack the alloy to some extent, according to strength of acid and temperature. The alloy seems extremely suitable for the manufacture of small cutting instruments and especially of table cutlery, for which purpose the property of taking an edge comparable to that of tempered steel, together with its silver-steel-like color, its high luster and its non-corrodibility, form a combination of most desirable properties.

Electrometallurgy of Iron and Steel.—According to a report received by the London *Electrical Review* from Stockholm, the Swedish Electro-Metal Company has formed a new company by the registration of the Electro-Metal Company in London. The object is the exploitation of the inventions of the engineers, Messrs. Lindblad, Grönwall and Stalhane (well known from Dr. Haanel's last Canadian report), in England, the British Colonies and North America. The capital of the new company is 550,000 crowns ($150,000) and two Swedish engineers are at the head of the undertaking. It is added that the Swedish Electro-Metal Company has commissioned the Iron Industry Bank to erect works using the electro-metal furnace near Trollhatten and the bank has sanctioned the expenditure of 250,000 crowns ($67,000) for this purpose and has made an arrangement with the owners of the Trollhatten water power for the supply of 3000 hp. The Swedish iron and steel producers are also interesting themselves in this type of electric furnace. The Swedish company, which established a Norwegian Electro-Metal Company at Christiania a year ago, still possesses the patent rights for the inventions in other countries. Mr. Eyde (of Birkeland-Eyde fame), who has withdrawn from the management of the Norwegian Power Company for the utilization of the waterfalls in Telemarken, has been elected on the board of directors, but will otherwise devote himself to the interests of the Norwegian Electrochemical Company, in which he and some Norwegian capitalists have secured the majority of the shares. It is now the intention of Mr. Eyde to take up the manufacture of iron and steel by means of electric smelting, according to the patents of Mr. Grönwall, which were recently acquired for this purpose. The scheme aims at the erection, it is said, of works at all places on the coast where the conditions are favorable.

Experimental Testing Plant in Canada.—An announcement published in the *Canada Official Gazette* gives the following information regarding a national experimental testing plant, concerning which those desiring further information may address Dr. Eugene Haanel, Dept. of Mines, Ottawa, Ontario, Canada. "The Mines Branch of the Canada Department of Mines is installing in Ottawa an experimental plant for the concentration of magnetic ores. When completed the plant will consist of a standard Gröndal concentrating unit, comprising an ore crusher, ball mill, and two Gröndal magnetic separators operating in tandem, the capacity of the plant being from two tons to four tons of crude ore per hour. The plant is being installed for the purpose of testing low-grade magnetic iron ores and sands, with a view to proving their amenability to concentration by the Gröndal wet system. Tests will be carried through for the determination of the following points: The extent of crushing required to raise the iron content of the crude to 65-70 per cent in the concentrate; the extent of crushing required to depress sulphur, phosphorus

or titanium contents to percentages acceptable to furnacemen; the number of tons of crude ore required to produce one ton of concentrate; the power consumed per ton of crude ore concentrated; the cubic feet of water used per ton of crude ore concentrated. It is expected that the plant will be ready for operation by the first week in November, 1910. Tests will be made free of charge on Canadian ores, but it is required that shipments shall be delivered, carriage paid, at the testing plant at Ottawa. Shipments of ore for testing purposes should be not less than 5 nor more than 20 tons, and it is particularly requested that shipments be made in sacks containing not more than 100 lb. of ore each."

PERSONAL.

Dr. **E. R. Buckley**, consulting engineer of the Federal Lead Company, Missouri, has gone to Idaho, where he will spend several weeks.

Mr. **Gelasio Caetani,** metallurgical engineer of San Francisco, Cal., has gone to Nicaragua on professional business.

Mr. **John Dern,** president of the Consolidated Mercur Gold Mines Company, Utah, was elected president of the American Mining Congress at its recent meeting in Los Angeles.

Mr. **E. Harms,** superintendent of the smelting works at Torreon, Mexico, has been visiting the metallurgical works of Colorado, Utah and Montana.

Dr. **Joseph A. Holmes,** Director of the Bureau of Mines, was in Denver recently en route to Washington after attendance upon the session of the American Mining Congress in Los Angeles.

Messrs. **Arthur Lakes** and **Arthur Lakes, Jr.,** announce that they have opened offices at 701-3 Gas & Electric Building, Denver, Col., for the practice of mining and metallurgical engineering.

Mr. **H. A. Megraw** has permanently located in San Luis Potosi, Mexico, where he is engaged in metallurgical practice.

Mr. **C. W. Merrill,** metallurgical engineer of San Francisco, has gone to London.

Sir **Alfred M. Mond,** of the Mond Nickel Company, recently inspected the company's property at Sudbury, Ontario.

Dr. **E. F. Northrup,** of the Leeds & Northrup Company, **of Philadelphia has been appointed professor** of physics at Princeton University.

Mr. **Irving E. Slater,** of Los Angeles, is on a professional trip into British Columbia.

Mr. **Maximilian Toch,** of New York City, specially known among the chemical fraternity by his work in the chemistry of paints and the publication of a treatise on the subject, which has become one of the standard books of this important branch, has been invited to lecture on the subject of new paint materials at the University College in London, under the auspices of the Paint and Varnish Society, on Nov. 3. He left New York on Oct. 25 by the steamship *Kronprinz Wilhelm.*

Dr. **Herbert G. Torrey** has resigned as chief assayer of the New York assay office, which position he has held for 37 years. He will devote his time to consulting metallurgical work.

The wedding is announced of Baron Dr. **Karl von Vietinghoff-Scheel,** editor of the *Chemiker Zeitung* of Berlin, Germany, and Miss **Zuleikha Hegeler,** of La Salle, Ill.

Digest of Electrochemical United States Patents Prior to 1903.

Arranged according to subject matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (Continued).

685,042, Oct. 22, 1901, William T. Gibbs, of Buckingham, Canada.

Resistance type, enabling fusion and reduction to be effected in an atmosphere free from carbon-vapor or dust. The furnace comprises an inclosed firebrick chamber having an arched roof, beneath and adjacent to which is a thin horizontal carbon rod resistor, extending between massive carbon blocks set in iron casings in the side walls. The material to be heated is placed on the hearth of the furnace beneath and at some distance from the resistor, being heated by radiation and reflection. The chamber has charging and discharging openings and a gas-outlet. A modified furnace is shown employing three superposed resistors connected in series.

685,717, Oct. 29, 1901, Oscar Frolich, of Steglitz, near Berlin, Germany, assignor to Siemens & Halske, of Berlin, Germany.

Arc type, especially for the production of calcium carbide. The furnace comprises a crucible mounted on a truck, having brick sides and a conical bottom constituting one electrode, with a large central tap-hole. The other electrode is a depending carbon tube. Pipes lead from the upper end of this tube downward to four burners opening radially into a chamber beneath the crucible. Air is also introduced at these points to burn the carbon monoxide drawn from the smelting zone; or the gas may be burned by vertical tubes opening from the top of the hollow electrode. Beneath the tap-hole is a conical protected hearth to receive the carbide, which is gradually lowered as the product forms. For the production of calcium carbide the mixture of lime and carbon is finely pulverized and forms a gas-tight inclosure around the arc, directing the gas into the depending electrode.

685,965, Nov. 5, 1901, Charles Paul Bary, of Paris, France.

Resistance type, for the production of stannic acid from tin. The furnace comprises a base of agglomerated magnesia, containing a narrow groove joining transverse rectangular recesses receiving the electric terminals. In use, molten tin fills the groove and recesses, and the tin in the groove is heated to the point of volatilization. Upon the base is a dome-shaped cover, having a central slit for the escape of the vaporized tin and partitions which extend downward into the molten tin in the electrode-recesses. As the tin vapor escapes through the slit, it is oxidized by air and is carried on by an air blast through settling pipes into a dust-collecting chamber lined with cloth and having staggered vertical partitions.

686,525, Nov. 12, 1901, James H. Morley, of Springfield, Mass.

Arc type, especially for the production of calcium carbide. The smelting chamber is a vertical clay tube, resting upon a carbon-block electrode. The other electrode is a square carbon rod depending into the tube and having a central passage. Two chutes for the supply of mixed lime and carbon extend downward to opposite sides of the clay tube. A hood serves for the collection and removal of gases and dust. The depending electrode is given an intermittent upward movement and a reciprocating rotary movement, to assist in stoking the material. The escape of gases from the settling zone is said to induce a current of air through the depending electrode. Two furnaces are illustrated, carried on opposite ends of a horizontal revoluble arm, carbide in one being allowed to cool while the other is in operation. With a current of 400 amperes at 60 volts, the upper electrode is 4 in. square and is raised 8 in. per hour. The arc is started by a carbon pencil initially placed in a central recess in the end of the lower electrode.

686,551, Nov. 12, 1901, Albert Simon, of Bordeaux, France.

Electrolytic furnace, for the production of iron, manganese and ferro-manganese. The apparatus comprises a crucible, having a hearth of crushed ferro-manganese in which are imbedded horizontal carbon cathodes. The upper depending anode consists of four or more carbons, inclosed in an envelope of crushed (manganese) slag compressed with tar and resin. The anode is surrounded by a brick inclosure having openings and passages for the escape of gases. The electrolyte, consisting of lower oxides of manganese and oxides of iron dissolved in fused calcium fluoride, is gradually melted by heat from two small carbon-block resistors, initially placed between the carbon

cathodes and the lower end of the anode. The normal current-density at the anode is 40 to 50 watts per square centimeter. The reduced metal is tapped off.

686,836, Nov. 19, 1901, Marcus Ruthenburg, of Philadelphia, Pa.

Resistance type, for fusing fine iron ore into globules or lumps. The electrodes are tubes of cast iron, constituting the cores of electromagnets and having opposed outlets in their adjacent polar tips. The charge feeds downward through the cores and out into the space between the poles, where it is held magnetically as a bridge, being here melted by the current traversing it. The poles are water-jacketed. Carbon plates may extend transversely through the poles, constituting floors on which the charge feeds out into the gap. Modifications are illustrated, comprising horizontal electrodes containing screw-conveyors, and duplicate pairs of electrodes.

687,505, Nov. 26, 1901, Marcus Ruthenburg, of Philadelphia, Pa.

Resistance type, for fusing magnetite into lumps fitted for subsequent smelting, or for reducing a mixture of iron oxide, charcoal or coke and flux. One electrode consists of a vertical conical tube of cast iron, the lower discharge end of which is water-jacketed. Beneath the outlet is a horizontal cast-iror. roller, constituting the other electrode. The material falls into the space between the lower end of the tube and the roller and is fritted or smelted by the current passing through it. The roller is gradually rotated, contact being made by a brush.

NEW BOOKS.

Arnold, J. O. On a fourth recalescence in steel. 12 pages, with illustrations and tables. Price, 6 pence. Sheffield: J. W. Northend.

Bain, H. Foster. More recent cyanide practice. Reprints of 77 articles by various authors, published between 1907 and 1910. 418 pages, illus. Price, $2. San Francisco: Mining and Scientific Press.

Bayley, W. S. Elementary Crystallography. 242 pages, illus. Price, $2. New York: McGraw-Hill Book Company.

Bowles, Oliver. Tables for the determination of common rocks. 64 pages. Price, 50 cents. New York: D. Van Nostrand & Company.

Burali-Forti, C., and Marcolongo, R. Eléments de Calcul Vectoriel. Translated from the Italian into French by S. Lattes. 230 pages. Price, in paper cover, 8 francs (retail price in New York $2.50). Paris: A. Hermann et fils.

Goldschmidt, Karl. Ein Schulfall socialdemokratischer Verhetzung. Der Kampf um die Pensionskasse von Th. Goldschmidt in Essen. 36 pages. Halle a. S.: Wilhelm Knapp.

Noyes, William A. A Test Book of Organic Chemistry. Second edition. 540 pages. Price, $1.50 net. New York: Henry Holt & Company.

Peddle, John B. Construction of Graphical Charts. 109 pages, 58 illustrations. Price, $1.50 net. New York: McGraw-Hill Book Company.

Frazer, Persifor, and **Brown, Amos Peaslee.** Tables for the determination of minerals by physical properties ascertainable with the aid of a few field instruments based on the system of the late Professor-Doctor Albin Weisbach. Sixth edition, revised to date. Price $2.50. Philadelphia: J. B. Lippincott Co.

Hale, W. Jay. Calculations of general chemistry, with definitions, explanations and problems. Second edition revised. Price $1 net. New York: D. Van Nostrand & Co.

Parr, S. Wilson, and **Wheeler, Wilfred Forrest.** Weathering of coal. Series of 1909. 43 pages, illustrated. Paper gratis. Urbana, Ill.: University of Illinois.

Stillman, Thomas B. Engineering chemistry. A manual of quantitative chemical analysis for the use of students, chemists and engineers. Fourth edition. 744 pages with 174 illustrations. Price $5. Easton, Pa.: Chemical Publishing Co.

BOOK REVIEWS.

Principles of Metallurgy. By **Charles Herman Fulton, E.M.,** President and Professor of Metallurgy, South Dakota School of Mines. Pages xii + 544; 187 illustrations. Price, $5 net. New York: McGraw-Hill Book Company.

A book to be highly commended. It fills a "gap" which has been somewhat of a "thorn in the flesh" to English-speaking metallurgists—begging pardon for the mixed metaphor.

The subject is treated from the broad standpoint of accurate scientific information. It is not very elementary; it is intended for serious students well prepared in chemistry and physics. It is admirably adapted for use in technical schools and universities, and for the practical man who wants to be abreast of the times in the scientific basis of his profession.

The keynote of the work is accurate, quantitative information about metallurgical principles, along with a clear description of the nature of the principles themselves. Our only criticism is that the work lacks a little in *balance*, that some parts of it are rather brief while others are gone into quite extensively; but all that is given is well given.

It is a book which should be in the hands of every metallurgical student and in every metallurgist's library.

J. W. Richards.

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The Journal of the Municipal School of Technology, Manchester. Vol. II. 298 pages. Manchester: The Municipal School of Technology.

This is "a record of investigations undertaken by members of the teaching staff of the several departments of the school during 1908." The papers included in this volume are of quite a diversified character and were presented before various societies. The following should be of special interest to the readers of this journal. W. Cramp and B. Hoyle, on the electric discharge and the production of nitric acid; by W. W. Haldane Gee, on electrolytic corrosion; by E. Knecht, on the mercerization of cotton yarns and on the action of oxalic acid on cellulose; and others.

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A Pathfinder—Discovery, Invention and Industry. With Edward G. Acheson's portrait as frontispiece. 143 pages. New York: The Press Scrap Book.

This most interesting volume is the record of the life and work of Edward Goodrich Acheson. It starts with the quotation from Shakespeare: "There's a divinity that shapes our ends, rough-hew them how we will."

The largest part of the work is taken from Dr. Acheson's autobiography, originally written for his family and not intended for publication. This makes the volume the more valuable and interesting. Acheson's work in electrochemistry, carborundum and artificial graphite, aquadag and oildag has long been recognized as revolutionary and fundamental. But this volume brings out the man as man in all his characteristic traits. It brings a great modern inventive and engineering genius nearer to the knowledge and appreciation of the general public. To ambitious youth this life story of Acheson should be an inspiration.

After introductory chapters on the reward of the Perkin medal to Dr. Acheson and on his ancestors, there follow six chapters of the autobiography, dealing with his boyhood and youth in Western Pennsylvania, his association with Edison at Menlo Park, his work for the Edison interests in Europe, and carrying his life story up to the thirty-fifth year. Then follow three chapters dealing with Acheson's monumental work on carborundum, graphite, egyptianized clay, direct reduction of aluminium and silicon, production of siloxicon, lubricating graphite, aquadag and oildag. The story is full of interesting details not heretofore known. It is a masterly human document.